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DESIGN AND ENVIRONMENT: TAKING INTO ACCOUNT THE INTERACTIONS BETWEEN THE SOCIAL ACTORS. THE CASE OF DOMESTIC PACKAGING

SYNOPSIS

This text discusses the problem of packaging waste through an analysis of the proposed solutions for reducing waste volume, in response to the European Directive 94/62 EC. We maintain that the difficulty of obtaining optimal solutions in practice is a direct consequence of the complexity of waste collection and sorting process. In the case study of plastics bottles (PET and PVC), we have observed that packaging design occupies a fundamental role in the recycling and hinders the adequacy of the result wished. Therefore, it is essential to take in account the chain of complexity of interactions in the design process.

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1 - INTRODUCTION

> *"Packages sometimes embody a different, horrifying kind of immortality. They are the Undead – whose lives are spent but who linger on to haunt and curse the living. No longer unravished brides, these are hags and zombies whose ugliness is as extreme as their one-time seductiveness. Empty and eternal, they are spectres of regret, lurid reminders of past indulgence. You can discard them, but they do not disappear. You can bury them, but they do not decay."* (Hine 97, p. 238)

This paper tackles the question of the environmental damages occurring in the final phase of the life cycle of packaging: its materiality and its alarming throw-way nature from which waste has become, in the eyes of society, a very serious problem.

When we discuss product and environment, two general aspects can be examined: the choice of raw material and production processes; the utilisation process and throw-away nature of the product. Thus, we recognise the composition of two pairs in the product life cycle, *material/production* and *use/post-use*.

Packaging becomes a problem once it is discarded, during the *post-use* phase.

When packaging fulfils its functions, they pass into another dimension, a world of waste, where harms take a more pejorative connotation. In society's view, packaging becomes a source for bad odours, visual and sanitary pollution. Moreover, the arithmetic increase in packaging waste is becoming an indubitable problem in the context of a limited amount of space. The exploitation of natural resources for the manufacturing of such ephemeral products, even incites research concerning materials employed and their treatment.

Packaging is responsible for 30-40% of municipal production of solid waste in developed countries. Each one of us disposes on average 1 Kg of packaging waste per day, totalling for example 6,3 million tons of waste packaging per year in France. According Eco-emballages[2] data 1,45 million tons of used packaging was recycled in 1998: 23,2% of the total volume of packaging waste. 550 thousand tons were incinerated: 8,8% of the total volume. This amount which is tending towards the objective foreseen by European Directive[3], which aims at a level of recycling or incineration of 50-65% of the total of packaging waste before 2001.

In this research, our objective is to search for the complexity of conflicts that restrain the establishment of desired results. We wish to know how considering these contradictory factors in the product design phase could help reduce packaging waste.

Applying a systemic approach, our aim is to know the actors present in the packaging life cycle. Our modelling has allowed us to conclude that problems of interaction and organisation of collection/sorting are at the basis of the problem.

2 - THE SOLUTIONS, FROM BIODEGRADATION TO INCINERATION

Packaging is composed of two elements: the graphical representation and the structure (Hine, 1997). Graphical representation is, above all, the mark of the product, a visual concept very important in marketing, consisting of the combination of colour, typology and logos conforming to a wished style. On the other hand, the structure and the physical shape of container, are not considered as the most important parts from a sales point of view. Nevertheless, in spite of its secondary importance for marketing, all discussions concerning the packaging/waste/environment problem involve materials use, the technologies developed to diminish its volume and the conception of mono-materials and recyclable packaging, etc.

Differently to a complicated problem, where the solution is restricted to only one domain, the subject 'packaging waste', rather presents itself as a complex problem. In this case, the outcome will be only possible through the co-operation of several experts in agreeing satisfactorily on a set of contradictory criteria. (Le Cardinal et al, 97 pg. 159)

First of all, as far as packaging design is cohered, the interdependence between structure and graphical representation emphasises this complexity. Therefore, the interaction of these two elements is fundamental in the different steps of packaging life as well as:

CONTAINING: is linked with protecting, carrying or stocking;

INFORMING: is linked with identifying and showing the product;

MARKETING: is linked with advertising and attracting the consumer;

to USE: is linked to ease usage and purchase.

Furthermore, it is also important to taking in account consumer features: age, sex, status, physical conditions, etc.

Besides, environmental issues applied to packaging contribute to another kind of complexity, that concerning many actors' point of view. For example, although graphical printing is one of the main part for marketing, the solvent and the pigment used may represent a real risk for environment.

The weakness of solutions to reduce packaging waste production comes from the carelessness in relation to these factors interaction. For a better fulfilment of solutions, it would be essential to understand every actor's roles and interests, as well as their interdependence and differences, but also, it would be necessary to analyse possible combinations or alternation of existing solutions.

2.1- 3R's : Reduce, Reuse, Recycle

Thus, the 3R's (reduction, reuse, recycling) became the slogan most used in relation to packaging and the environment.

For ***reduction***, two possibilities are proposed: (Campos, 95) (Kazazian 95, p. 101-108)

1) To reduce from the source: this concerns the reduction of material used by packaging, either in diminishing volume of material, or in reducing secondary packaging. A very meaningful example is the research undertaken on aluminium cans. Today the weight of these cans reaches less than 11 grams meaning a reduction of about 20% in relation to the last 10 years. (Picchi and Strina, 97) However, the thickness diminution can reach limits in the other stages of packaging life for example the quality of conservation or the resistance for transportation and stocking.

2) To packing a bigger quantity of product per volume of material used in packaging, meaning working with concentrated products. In this case we observe the importance of the consumer's commitment, while preventing or while facilitating the good achievement of the proposition.

The complexity is even more remarkable if we consider the reduction as the diminution of the waste mass produced. In this perspective, we are no longer concerned solely about an adoption of a technical solution, taking during the production, but about the need to consider the entire waste treatment chain: the household, the selective collection in the public dustbin, the sorting centres, the branches of treatment. It results in a very expensive process where the simplification is urgent.

In relation to ***reutilisation***, four situations can be considered: (Campos, 95) (Kazazian 95, p. 117-120)

1) "*Re-employment*": where the packaging assumes the same function several times in succession. They can be "re-employed" by the conditioning agent or by the consumer in a system of refill.

In the case of *re-employment* makes by the conditioning agent, empty packagings must be returned by consumers to the seller, who returns them to the distributor, who transports them at the conditioning agent closing the cycle. The functioning of this process depends of all agents involved, and also of the packaging resistance to support the same cycle many times.

Moreover, in the case of *re-employment* makes by the consumer, it concerns a personal commitment that will depend of several factors as well as the easiness of the task, the relation price/gain, the precise information on advantages acquired, etc.

2) *Multifunctionality*: packaging that offers one or several differing functions, for example, the automotive oil can that also permits the collection of the used oil. It also constitutes a setting of complexity observed at the connection between producer's proposition and consumer's understanding, established through the interfaces: formal and graphical reports indicate a possible second use.

3) *Recuperation*: the recovering of objects, for example wood cases containing bottles of wine can be transformed into rustic and aesthetic furniture elements.

4) *Turning*: it is an action independent of the designer, achieved on the post-use stage by the user or by the artist.

With a few exceptions for *re-employment*, while depending on the product and the country, the packaging reuse remains very marginal.

On the other hand, ***recycling*** is a key process for resolving the problem. It constitutes the re-transformation of an used material into a newly useful material. All materials packaging is technically recyclable, **but this does not imply that they are effectively recycled**.

The problem of the non-recycling resides in the complexity of the collection and sorting process which generate heavy economical constraints.

The use of recycled materials can even present technical limits, especially in relationship to food plastic packaging and products for pharmacy. However, its use can be seen immediately in relationship to other products, while adding the value to the material, like the clothes made with fibre manufactured from the recycling of PET bottles.

2.2 - Biodegradation and composting

Another solution that can be considered is the use of ***biodegradable*** packaging. A term much more commonly employed for plastics, biodegradable materials do not attract a large enough interest for industry, either because of their price, or because of their properties and the microbial proliferation

that they can provoke. In addition, these materials can even subsist like a new substance and can induce unknown ecological consequences.

Biodegradable packaging is not yet used as an environmental solution most probably because even though it facilitates the disappearance of waste, it does not solve the question of biochemical reactions[4].

Nevertheless, some cardboard packaging – 7% of the domestic waste weight – is recovered by the ***composting*** method, a process of biodegradation. (Kazazian 95, p. 87-93). Even in this case, it is the quality of collection/sorting that will guarantee the quality of composting result.

2.3 - Incineration

The combustion of urban solid waste, called ***incineration*** or thermal valorisation, constitutes a highly ambiguous solution. It is considered by several as a more efficient technical proposition for the elimination of waste. On the other hand, others object about the pollution provoked by smoke, ashes and poisonous substances emitted by incinerators.

On one side, if damages come from technical problems of incinerators maintenance, on another side they can also be induced by mixture of packaging materials.

The incineration is a solution of waste valorisation as a source of energy. Packaging waste, in particular plastics, give a very good energising value. In relationship to the fuel-oil, that produces 10000 kcal/kg, packing materials produce[5]:

- plastic: 9000 kcal/kgs;
- paper - cardboard: 3000 kcal/kgs;
- wood: 3000 kcal/kgs
- organic waste: 1800 - 2400 kcal/kgs.

On the other hand, it is necessary to draw attention to the fact that plastics are the most important polluting material in the burning process. Packaging materials, that can emit toxins on the atmosphere are[6]:

- materials containing chlorine: PVC (polyvinyl chloride) used in packaging;
- materials containing heavy metals: chromium, cobalt used in printing;
- materials containing organic pigments: unknown composition in combination with solvents, resins, glues, etc. can produce some non-synthetic molecules.

In spite of the variety of solutions proposed, the biggest quantity of domestic waste, including packaging, is still poured into public discharges.

The inefficiency of these technical solutions is bound most probably to the complexity presented by the problem. To solve the question requires the interaction of several factors, as difficulties of collection and sorting, which can provoke possible conflict situations. Attaining a satisfactory result implies the consideration of these circumstances, at the very outset, in the packaging design phase.

3 - COLLECTION AND SORTING

Packing collection and sorting are the fundamental roots of the problem. The complexity and the difficulty of these operations even generate disruptions in the recycling of certain materials, which nevertheless, easily recoverable. Incineration, composting and reuse can be, also, more effective while receiving well sorted waste. Otherwise, the reduction of volume and variety of materials employed in packaging can facilitate considerably the task of collection/sorting.

The collection is generally accomplished in two distinct ways: (SMVO, 98)

- Voluntary collection via containers placed in public places: for glass, paper and cardboard, bricks, metallic boxes, bottles in transparent or opaque plastic, clothes, oil, etc.;
- Classic township collection at householders.

Photo 1: Manual sorting centre.

Waste already collected, goes either to discharge, or to sorting centres. In these centres, sorting is often manual, therefore small materials, small papers are difficult to sort. In this case, these materials will be either fermented with the organic waste or incinerated with other materials, in particular plastics. (Photo 1)

It is important to underline a very problematical side of this process. Beyond the evident depreciation of the activity, this manual sorting even concerns the question of hygiene conditions and security of the task, where health problems must be foreseen all the time. This point constitutes a real paradox. On one hand, the refusal of the activity from society brings a massive incineration of packaging waste. On the other hand, the refusal of waste incineration adopts a recycling politics that induce the continuation of manual sorting. This is also encouraged by creation of employment discussion – But, for which type of job!

Will we get in the future a quality in collecting/sorting organisation so that sorting centres will disappear? or will these centres be automated?

Anyway, other services can encourage collection.

These are waste exchange programs set up in Brazil, for example. Two programs can be mentioned:

The project “Câmbio Verde” (green exchange), created by the city of Curitiba, foresees the exchange of a bus ticket, or of agricultural products of the season, for every rubbish bag of 7,5 kg full of packing waste sorted. (Bertussi and Ferreira, 95)

At Belo Horizonte, the program “BH Reciclada” (BH recycled) organise a system of collecting aluminium cans, where private enterprises exchange a certain quantity of cans for school materials. (Tavares and al, 95) Also conscious about the existence of casual collection in the city, made by “catadores” of paper (in majority homeless), township, through the program, assumes functions of logistical and operational support to this work.

3.1 - The complexity

The process, collecting/sorting = recycling/incineration/composting, form a system where the good functioning depends on the overlapping of two main factors: the adhesion by the public, and the governmental organisation.
In relation to townships and industries, initiatives are stimulated by legislation. For the community, it is an environmental awareness that grows due to programs and advertisements made by townships.

Otherwise, households have an essential task in the activity of collecting/sorting: the mixture of domestic waste can greatly complexify the valorisation process. Indeed, the refusal to carry out sorting by citizens is low enough in France, on average of 20%[7]. Nevertheless, the weak performance of programs can be due to other important factors: How can we identify the various types of materials? How can we have several dustbins in one house? How to transport the sorted waste? Etc.

These difficulties, closely linked to the product, have urged us to try to understand how, through design, it can help to reach the reduction of waste production and what the role of conception could be in this complex setting.

Of all these questions ensue the necessity of a modelling, allowing designers awareness about these acts and to project the impact of their actions on the system.

3.2 - Modelling

This work has been driven by a modelling approach[8], taking, first of all, the producer and the consumer as being the two main actors of the system. These two agents are located in the precise and very different phases, but not yet interdependent.

Packaging constitutes a problem but only once it is disposed. If it becomes waste submitted to any type of valorisation, going to the public discharges, it means that the system has broken down.

The critical moment is the passage from use to the post-use stage. So, to that the system does not break down and so that it is re-established, packaging waste must be either reused, recycled or incinerated.

However, its reestablishment is submitted, precisely, to the overlapping of all actors composing the chain of:

- The producer of the contents: who industrialises the contents, who wraps and introduces the wrapped product on the market;
- The producer of packaging: who industrialises and provides the packaging to the producer of the contents in agreement with conception specifications;
- The seller: who makes the merchandising of wrapped products.
- The user: who buys products (wrapped contents) in order to consume(or to use) them;
- The "*recuperator*": who treats the waste: collecting, sorting out, incinerating or recycling it. Who gives a new value to garbage.

These actors are regrouped, indeed, by the two *borders* underlined earlier, production and use, characterising well, our model by the representation of two pairs: material/production, use/post-use.

The waste production is a event that occurs in the second pair: use/post-use.

Also, interacting in this process are the designers. Product design activity tries to unite the interests of both pairs.

This stage, at the very outset in the system, is characterised by the decision making, taking into consideration of several aspects: aspects concerning the contents packing, technical aspects of production, aspects concerning users, aspects of economical interest to the producer and the consumer, etc. This also allows the taking into consideration of environmental aspects including their complex character.

The question is, therefore, to identify the interactions existing between the actors, their common interests and the possible conflicts that hinder the good functioning of adopted solutions. Our proposition is to observe these events from the design's point of view in order to integrate them to the product conception. Therefore, a feedback of constraints, lived during use/post-use, will be able to overlap into the production phase.

4 - PET AND PVC BOTTLES

Plastic bottles manufactured from PET and PVC are a very good example to illustrate the incoherence between packaging conception, waste treatment, and the absence of collection/sorting consideration.

Mono-materials, both bottles are used for the same products of: water, kitchen oil, juice, soft drinks, etc.

The PET (polyethylene terephthalate), used notably for package drinks, present two advantages in relationship to PVC (PolyVinylChloride): it is much more recyclable and it is much less polluting if it is incinerated. On the other hand, PVC is certainly cheaper than the PET.

PET is a material still in development, because it presents a lot of recycling possibilities. The quality of its recycling depends on the quality of sorting set: sorting, complementary sorting (re-sorting by automatic machine), washing (for a very pure granulation). Recycling can be made to get mainly fibres (short fibre for cloth), new packaging, or technical pieces (in a minor way).

PVC is recyclable as well, but its use is often limited (for the manufacture of tubes, for example). Otherwise, it is one of the main materials that can give out toxins in the atmosphere while incineration, emits hydrochloric acid. PET, on the contrary, emits CO2 and H2O.

4.1 - Packaging design and problems of sorting

Regarding water bottles, the identification between PVC and PET at sorting, the presence of three different materials, as well the shape of the bottles, constitute the mains obstacle points for the recycling process.

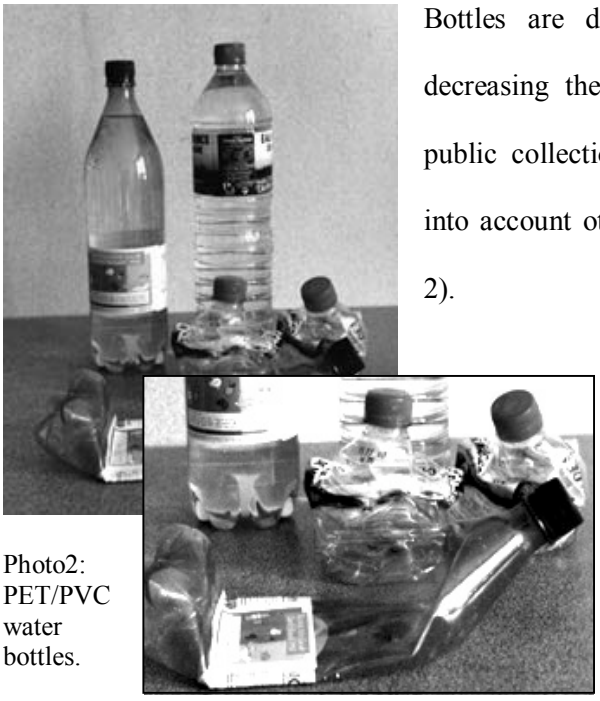

Photo2: PET/PVC water bottles.

Bottles are designed with an ideal shape for compression, decreasing the volume of waste and facilitating domestic and public collection. Nevertheless, this compression does not take into account other problems that it causes during sorting: (Photo 2).

1. Compressing bottles means compressing their labels together. Removing the labels is a very complicated operation to achieve in the home. Compressed, it will be much more difficult to remove then.
2. To maintain the bottles compressed, it is necessary to re-close them again with their plugs.

It is in the sorting centres that problems arise. First to remove labels, whereas in the majority of centres sorting is manual and, even though the label removal is technically possible by chemical processes, this task would provoke a rise in cost.

In the same way, identification between PET and PVC at sorting centres is made notably by the recognition of the mark of the packaging written on the label. If the labels are crumpled, the mark is more difficult to recognise. These transparent packagings always have the same aspect and the same colour. Their visual identification is very difficult even for an expert.

Problems occurring at sorting centres are also noticeable in relationship to the removal of the plugs. For a lucrative recycling, it will be necessary to remove the maximum of "pollution" (plugs and labels) from the materials to be recycled.

All these problems are clearly descended from the design of the product, where the non-technical and organisational aspects of collection and sorting have not been taken into account.
Simple solutions taken by product design could greatly improve the recycling of these materials. It could be, for example: the visible marking of PET/PVC's signs on the bottles, or its pigmentation in different colours according to the resin; the elimination of the label by direct printing, or the use of a similar material; the rethinking of the closing and compression system, as well as the proposition of modular shapes that facilitate domestic sorting, etc.

These observations allow us to sustain the importance of understanding the complexity of the events to solve environmental problems – problems that are especially characterised by the interaction of several factors. The identification of interactions, their interests and disagreements, considered at the outset by the product design process, will certainly help to reach environmentally aware solutions, by the sum of the contributions, however small, of each agent.

5 - CONCLUSION

This work is currently being developed in the setting of a doctoral research, whose theme concerns industrial design and environmental considerations, in the aim to verify the contribution of product conception to the sustainable development perspective.

In this part of the work, we analyse the integration into product design, of the complex interactions owns of environmental problems caused by packaging waste production.

We observe that, in spite of those solutions already implemented and those proposed, the inefficiency of its results is closely bound to the organisational complexity present in the process of collection/sorting waste.

Through the study of PET/PVC's bottles, we note that product design is at the centre of non-technical problems.

To take into account these interactions in the product design phase is therefore fundamental.

We propose to identify the interactions through a model composed by two pairs: *material/production* and *use/post-use*. The aim is to compose an inventory of all the actors present in both pairs, allowing to take into account their common interests, their contradictions and the possible conflicts produced, that prevent the optimal application of solutions, and assimilating them into the product design process.

Our approach comprehend the environmental issues beyond a merely "ecological" view. The objective is, indeed, tackle the idea of sustainable development, in which the most important is to understand and to consider the intrinsic complexity of the problem. This understanding will allows us to settle a product design procedure that integrates environmental factors, social organisational factors, and manufacturing factors, in order to generate a trajectory of sustainability.

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NOTES

[1] - Scholarship allows by CNPq (National Council of Scientific ant Technological Development – Brazil).

[2] - Éco-emballages is a private company declared as public interest, created on the initiative of industrial and public powers in August 1992. It is the mediator and the interface between the actors, that collect, sort out, treat and valorise the domestic waste. [www.ecoemballages.fr - December 1998].

[3] - The European Parliament and the Council of Europe issues the Directive 94/62 in December 20, 1994, concerning packaging and the management of packaging waste in Europe. In its 6th article, of valorisation and recycling, the directive determines:
- in five years between 50-65%, in weight, of packaging waste will be recovered. From the date when the directive was transposed into national rights, until June 30 1996 maximum;
- in the setting of this objective and, in the same delay, 25-45%, in weight of the set of materials of packing will be recycled with a minimum of 15% in weight for every material.

[4] - Interview with Marc Cheverry, co-ordinator of Collecting-Recycling team of the Department of Municipal Waste - ADEME (Agency for the Environment and Management of Energy – France).

[5] - Interview with Gérard Antonini, director of the scientific department of Industrial Processes Engineering – UTC, Université de Technologie de Compiègne.

[6] - Gérard Antonini.

[7] - A survey achieved by Eco-emballages demonstrates that about 11% of public are against, about 21% are hesitant and the majority, either 66% are favourable. (Eco-emballages, 97)

[8] - The modelling of the system packaging/waste has been developed gradually in three stages, according to:
- the methods described by Jean-Louis Le Moigne and by the OCC method developed by the IDTH team - UTC,
- the method PAT-Miroir, Division IDTH - UTC,
- the methods used in systems safety proposed by Jean-François Guyonnet.