

# Aspects of Sustainability in the Development of Corrugated Cardboard Packages for Exportation Based on a Product-Service System Context

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## Abstract

The present article discusses key guidelines that must be considered on developing, producing, using and disposing corrugated cardboard packages, particularly those applied within Product-Service Systems (PSS). This research was based on a case study developed within an automotive corporation and focuses on the packaging system of components used on the process of painting and insulation. The results have shown that is economically viable to obtain a more eco-efficient PSS for automotive packaging systems and, also, enable production practices present on the automotive industry, such as Just-in-Time and TQM.

## Keywords:

Packaging, corrugated cardboard, product-service systems

## 1 INTRODUCTION

Increasingly demanding environmental requirements for packaging, both at external and internal markets, have forced corporations to search new alternatives to attend their clients and conquer new market segments. In terms of sustainability, the trend points towards a dematerialization of consumption by means of solutions such as Product-Service System (PSS).

A PSS can be obtained through means such as leasing and shared usage of goods. In this context, the use of reusable packages has been a growing practice, with environmental advantages in terms of materials life extension, reduction of resources consumption and waste generation, among other benefits. In the case of corrugated cardboard, the use on reusable packages is a significant design challenge since it is usually seen as a material with little life span.

Packaging is a great concern to the Automotive sector since it is quite normal an average car to present more than ten thousand different components. In the case of Brazilian Automotive Industry this is particularly relevant because of recent environmental pressures from internal and external markets.

The Brazilian automotive industry was implemented in the 50's. Lately starting on the 90s it suffered great changes due to the economy opening made by the government. The most significant changes were the search for more efficient production practices and a gradual involvement of Brazilians on the design phase.

Currently the sector presents factories concentrated on a few cities and a dispersed demand. More than 60% of the produced vehicles are until 1000cc and a growing number of car parts are now engineered and produced locally. One of the characteristics of the Brazilian automotive industry is the high idle capacity of its factories (about 40%), which means a potential for producing extra 1,2 million of units.

The supply chain of this sector is strong and competitive and competitive when comparing to other countries such as China and Mexico. Little more than one quarter of the Brazilian exports in this sector follows a CKD regimen (assembly in the destination).

In world-wide terms, the automotive industry represents currently about 10% of the world-wide circulation of the industrial capital (IUPERJ, 2005). The participation of the

automotive industry in the Brazilian GIP is of about 3%, and represents 27% of the exports approximately. The sector presented growth of 4,4% in production and 5,6% in exports in 2006 when compared to 2005. With regards to the generation of jobs, the number of generated jobs surpasses 1,3 million, between indirect and right-handers (CUT, 2005).

Currently one of the biggest challenges of the automotive sector is to achieve the Agenda 21 goals and requirements and environmental standards adopted by the automotive sector and others (ISO 14000). Some of the Car Factories in Brazil have already obtained ISO 14001 certification which now enables an audit of the environmental management practices.

Section I of Agenda 21 deals with the needs of changes on the consumption patterns and this is the area where design can generate a significant contribution. PSS applied to packaging systems is one of the approaches that can enable the Automotive industry to achieve environmental requirements and, at the same time, achieve its economical needs. The growing search for ISO14000 certification within this industry is an indicator of its adherence to Agenda 21. However, there is a growing need for a wider focus on the total cycle of products and goods. Hence, the present study intends to contribute with a different view on the packaging system for this industrial sector.

### 1.1 PSS for Packaging

#### *Definition, characteristics and examples*

Between the many possible strategies for sustainable development, PSS – Product Service Systems (or sustainable service systems) have a great importance because are focused on dematerialization of consumption (MANZINI, 2002)<sup>1</sup>. This change is based on the transition from wellbeing by ownership objects to wellbeing by services benefits, replacing the product ownership from the consumer to the manufacturer. Jelsma and Knot (2002)<sup>2</sup> defines the idea of service system as an interrelated set of products and services, as well as the needed necessary organizations, nets and physical, regulating and institutional infrastructure, that, together, allows the user to have his/her necessity fulfilled. There are many examples of PSS already in use in the market such as equipment location and leasing; home care outsourcing activities; post-purchase services; collective usage and result-oriented contracts. These

kinds of PSS systems are described and detailed by Heiskanen & Jalas (2000) and Hirschl et al (2000) apud Jelsma e Knot (2002).

A PSS can basically bring benefits for the users by three different ways: by generating additional added value for the product life-cycle; enabling the end result of consumer needs or acting as an access platform for the consumers. It has some successful cases in the Europe, as of the companies Allegrini, AMG e Greenstar, among others (UNEP, 2004)<sup>3</sup>.

#### *Methodologies and tools*

To develop a PSS there are a number of methods, such as MEPSS – Methodology for Product Service Systems, proposed by Halen, Vezzoli & Wimmer (2005)<sup>4</sup>. MEPSS is directed to the industry and consists of five basic phases: strategical analysis, opportunity exploration, concept development, development/detailing of the chosen concept and preparation for implementation. Beyond the MEPSS, there are already other auxiliary tools such as the TRIZ method directed to the innovation (MANN and JONES, 2001) or the use of user-behavior scripts (JELSMa e KNOT, 2002).

One of the most interesting strategies for PSS planning is the creation of scenarios, also called Design Orienting Scenarios – DOS (WILLIAM et al., 2001)<sup>5</sup>, used in projects as the SusHouse (1998-2000) and the Sustainable Everyday (MANZINI and JEGOU, 2003)<sup>6</sup>. In these projects, the scenes are communicated by means of storyboards, during multidisciplinary workshops, in which the discussion of the ideas generated by experts from different fields of knowledge.

#### *Socio-ethical and economic aspects*

There are already initiatives that explore some principles of PSS on packaging. However, these initiatives frequently do not explore all potential of PSS systems and often do not present the necessary change on the business process required by such systems.

Implementing PSS on corporate clients appears to be easier than domestic clients. Cultural and social restrictions are lesser relevant within production systems since a more pragmatic approach is easily accepted as long as it makes economical sense. Whilst within a factory an environmentally benign practice can be seen as a source of competitive advantage on a domestic environment there will other subjective factors that might even become a barrier for a PSS system (for instance: well-being, personal satisfaction, emotion, culture, status, etc.).

#### *Environmental aspects*

The development of a PSS directed to the protection and transport of products not only must be made from the analysis of the product, but also for its entire life-cycle (order process, production, distribution, use and discarding). Higher attention has to be given to the stage of use, searching to extending the life cycle of the packaging system and, also, optimizing its usage during the transport and storage.

For the development of the packaging system, all known strategies of sustainable design must be considered (MANZINI & VEZZOLI, 2005)<sup>7</sup>:

- Minimizing resources: to reduce the use of materials and energy;
- Choice of low environmental impact resources: to select the materials, the processes and the energy sources of bigger eco-compatibility;
- Optimization of the products life: to project products that can be durable;

- Extension of the materials life: to project in function of the valuation (re-application) of the discarded materials;
- Easiness of disassembly: to project in function of the easy separation of the parts and the materials.

These strategies were used for material selection and the development of the all design concept of the packaging concept on the case study. The next section presents key aspects of the material selected for this case study.

## **1.2 Corrugated cardboard**

### *Environmental aspects*

The corrugated cardboard was found suitable for this project due mainly to the fact that it uses about 18% of recycled material in plates and not aggressive auxiliary materials (CEMPRE, 2004). Other key aspects for its selection in this project included:

- It is considered a neutral material for the use, does not present known emissions;
- It presents relatively low impact in sanitary landfills, had to be biodegradable since that being correctly prepared;
- It is collected in great volumes and identified for separation, resulting in lower costs of processing;
- It can be mixed to other wastes, becoming nitrogen source for the microorganisms, an important aspect in decomposing processes.

According to CEMPRE (2004) Brazil has recycled 79% of its cardboard in 2004. The industry of packaging is the one that more uses recycled cardboard, representing almost 2/3 of the recycled cardboard produced in the country. However, the recycling process in the country faces various barriers such as the use of insoluble inks and resins and the presence of wax, plastic, spots of oil, land, wooden pieces, strings, ropes, metals, glasses, among others, beyond the humidity. The mixture with recycled paper fibers that had lost the original resistance also makes it difficult the recycling process. It is recommended that contaminating materials do not exceed 1% of the volume and that the total loss in the re-processing not pass 5% (CEMPRE, 2005).

### *Aspectos sócio-culturais e econômicos*

The corrugated cardboard has presented growth in the consumption in the whole world, something not desirable in point-of-sight of the sustainability. From a sustainable design point of view the aim of a Designer has to be a reduction in the consumption of natural resources such as cardboard. The corrugated cardboard packages market is estimated on around U\$ 459 million/year (WPO, 2005), with yearly growth of about 4,2%. Brazil is responsible for almost half of the cardboard produced in Latin America, and the food sector is the largest consumer (36%) (ABPO, 2005).

The industry of the corrugated cardboard generates jobs mainly in the plate production and on recycling factories. Only in Brazil this industry has generated about 13.900 jobs in 2002 (ABPO, 2002) in the plate production and more than 28.000 jobs in the recycling industry (BRACELPA, 2002). Statistics of IBGE (2002), shows that the activity of collecting paper for recycling employs around 25.000 people on formal jobs. The "street collectors", working on the informal markets sum around two hundred thousand people in Brazil (ANAP, 2005).

### 1.3 Research method

This research adopted “case study” as the main strategy to carry out the field studies. This case study was developed in three main stages.

- The first stage involved the characterization of a particular production process of an Automotive Plant in Brazil and its correspondent logistics, the workbreakdown structure and the dynamics related to the packaging of components. The study involved an analysis of the entire flow of packages, from the supplier to the assembly line;
- The second stage involved the development of new solutions for the packaging process, now considering the usage of a PSS system. This stage also involved the build up of a ten year scenario (2006-2016) for the process and its correspondent technology in order to foresee future needs of a PSS system focused on the needs of this case study;
- The third stage constituted of a workshop within the company in order to present the diagnosis, evaluate the feasibility of the PSS system and development of a implementation plan. The present article reports the actions implemented so far and the benefits that were observed and the difficulties identified on implementing a PSS system within the Automotive Sector.

## 4. Results & Analysis

### Characterization of the Automotive Component and Its Production and Logistics

The first stage of the case study (characterization of the productive process) was made by means of mapping of the process, photographs and interviews with professionals involved on the logistic and production of the host company.

The study focused on the packaging of components used to protect car body parts during the painting and insulation process. These parts will be called in this paper “Chapelonas” (Figure 1a). These components use polyethylene of low density (PEBD) that have the temporarily function of closing the openings of inferior part of the vehicles (figure 1b) in order to allow the waterproofing and protection process which involved the application of a thermoset material (PVC mass).

One car used an average of 10 “Chapelonas” with a variety of sizes and quantities for each model of vehicle. There were various suppliers for these parts and material they used for packaging was corrugated cardboard boxes. The production of “chapelonas” used a thermo-forming process, with slight specification differences particularly on color and thicknesses. Each component traveled an average of 500 kilometers to get into the factory, despite its low weight and low complexity of production technology.

#### Problems Detected Within the Factory

It had been detected losses of time due to necessity of moving the components from one type of packaging (cardboard) to other type of packaging (Polypropilene) within the factory. Also, various packages have shown a volume of components below the required level and that fact was not detected during the delivery control.

Hundred percent of all components and cardboard packages were discharged after one usage. Moreover, it has contamination of “chapelona” plastic with the thermoset mass what it disables its recycling. With this, the discarded material finishes being used as load in other composites or is incinerated.

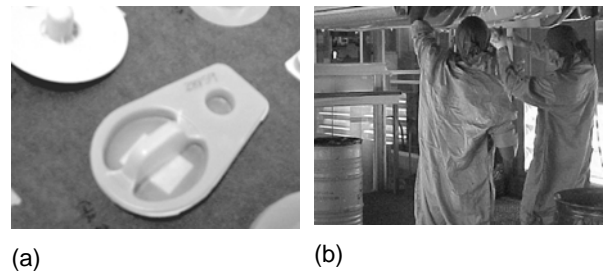


Figura 1: plastic “chapelona” (a) and the application at the production line (b).

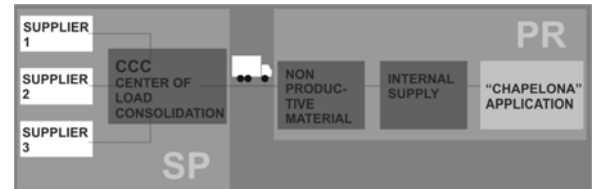


Figure 2: main involved stages of the process in the use of chapelonas plastic, and the ones that do not add value to the end item (in red).

The mapping of the process was used to detect the stages of the process that do not add value to the final product (the automobile), being considered, therefore, as wastefulness generator (figure 2). This wastefulness can be of time, energy or resources (financial, material, human). In such a way, was detected an excess of stages of transport, storage, wait, inspection and control of the material. The reduction of this excess was one of the main targets in the following stage of the project (generation of solutions). Beyond the mapping, it was made an analysis of the task of application of “chapelonas” in the vehicles, what it in such a way allowed the ergonomic adequacy of the packings to the operators how much to the logistic one, based on pallet standard measures of 120x120cm (ABPO, 2005).

In the second stage of the project they had been proposals solutions from two chronological clippings: possibilities for 2006 and 2016. In the first case, they had been proposals solutions that did not imply in deep changes in the productive process. These solutions had been thought from the five main criteria of design sustainable, and were used the system strategy product-service (PSS) with the use of reusable packings. The presentation strategy involved the use of virtual models and prototypes in corrugated cardboard. For 2016, they had created proposals from the use of scenarios, and the study of two possibilities: to have or not plastic “chapelonas” in the production of the automobiles. In this in case that, the presentation strategy involved the use of storyboards to communicate in more efficient way the concept created, during one workshop carried through next to the professionals of the next areas of production to the project (logistic, painting, environmental management and others).

The possibilities for 2006 had been contemplated in two proposals: an only kit for each model of automobile and individual boxes for each plastic type of “chapelona”. Both had been projected to be collapsible after the use so that some times could be carried.

In the case of the integrated kit (figure 3), the packing adds inferior supports that make the function of pallet, doing without the use of this. It presents internal divisions and superior plate, both dismissable ones and made in recycled cardboard of low cost.

The individual reusable box (figure 4) presents a cover that are incased under the box at the moment of the use,

and an inferior part of fast assembly/disassembly that optimizes the return of the packing.

Both the solutions had been developed preventing the use of components and materials that made it difficult the recycling of the packing when discarding. Also by this any process of waterproofing (wax, varnish or others) for the corrugated cardboard was not used. The parts that demand the glue use are glued with glue PVA, more compatible with the cardboard. Finally, the two alternatives present graphical application printed in flexography in an only color, to reduce the cost. This impression has the function to add ambient information and of use, that they search to create a bigger involvement of the professionals who manipulate the product in the direction to prevent the premature discarding of the packing.

In logistic terms, the compacting of the packing allows a reduction of volume of 3:1, that is, to each three trucks that arrive with plastic "chapelonas" one return with the folded packings.

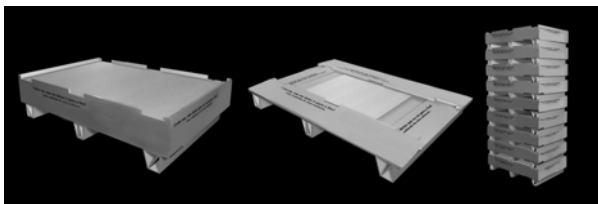


Figure 3: integrated kit for each model of vehicle, collapsible and in corrugated cardboard.



Figure 4: individual box for each model of "chapelona", collapsible and in corrugated cardboard.

Related to the alternatives for 2016, three alternatives for scenes without "chapelonas" and three of scenes had been generated where still these components existed. Electrostatic waterproofing, more intelligent robots and handles with reusable and durable "chapelonas" are part of the first approach, while second contemplates the reduction of the number of "chapelonas" in the development of the vehicle, use of integral masks and supply for pipes.

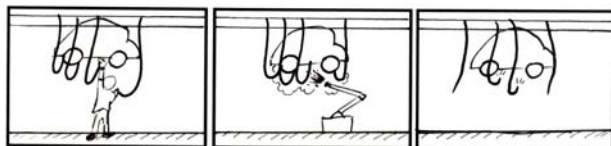


Figure 5: storyboard of scenario with use of handles and reusable and durable "chapelonas".

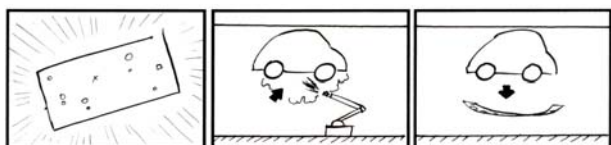


Figure 6: storyboard of scenario with use of integral mask for the inferior part of the automobile.

## 2 CONCLUSIONS

The initial results point the viability of using sustainability guidelines, how much of some tools to explore opportunities in the methodology for systems product-service (MePSS). Between the used tools, storyboards of scenes had revealed particularly efficient for the clear and fast communication of the planned concepts. The new proposals it was not evaluated of quantitative way, what will be made with aid of the ACV – Life-Cycle Analysis. In the same way, a qualitative evaluation will be made by using SDO-MePSS software. In general terms, however, the strategy of systems product-service revealed adequate, and the economic feasibility integrates the continuity of this study, to be made in set with the industry.

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