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Analysis of footwear development from the design perspective: Reduction in solid waste generation

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ABSTRACT

Environmental quality is an increasingly discussed topic, being a global and urgent issue. Among the environmental problems, it is highlighted in this study the great generation of solid waste, especially associated with the footwear production, which is an important sector of the Brazilian economy. In this context, design is considered a potential tool to minimize the negative environmental impacts of this sector. Thus, this research aims to analyze the development and production of shoes from the sustainable design perspective to reduce the leather waste generation. Thus, a case study in a footwear company situated in the Brazilian state of Rio Grande do Sul is presented. Data was collected from *in loco* visit, observation and interviews. Subsequently a content analysis relating the collected data and the theoretical framework is presented. Results demonstrate that the application of concepts and strategies from sustainable design in the development and production of footwear, in the studied company, generated satisfactory results in terms of minimizing leather waste without losing competitiveness.

Keywords: design, sustainability, solid waste, footwear development.

Introduction

The footwear industry is an important pillar of the Brazilian economy (Abicalçados, 2015). However, it is known that environmental impacts are inherent to the footwear production, particularly those impacts associated with the generation of high toxicity solid waste (Alves and Barbosa, 2013), which culminates in relevant environmental risks (Yabroudia *et al*., 2013; Bouzayani *et al*., 2014; Vrijheid, 2000). This situation highlights the need to adopt sustainable measures in the footwear production, in order to minimize the negative environmental impacts related to the generation of solid waste, but without losing competitiveness.

In this study, the sustainable design principles and strategies are presented as potential tools that can promote further approximation of footwear production to the ideals of sustainable development. This hypothesis is based on the design ability to influence the environmental aspects involved in each stage of the product life cycle (McAloone and Tan, 2005; Manzini and Vezzoli, 2008; Platcheck, 2012), and even generate changes in social behavior (Meroni, 2008; Ceschin, 2012) encouraging competitive advantage through eco-innovation (Marchi, 2012; Jänicke, 2012). Thus, industrial design is defined by the International Council of Societies of Industrial Design (ICSID, 2016) as:

> *[...] a strategic problem-solving process that drives innovation, builds business success, and leads to a better quality of life. [...] It links innovation, technology, research, business, and customers to provide new value and competitive advantage across economic, social, and environmental sphere.*

Based upon this premise, the present study aims to analyze the development and production of children's shoes in a Rio Grande do Sul industry from the perspective of design for sustainability for the reduction of leather waste generation. Therefore, is presented a theoretical framework, addressing the evolution of design in terms of concepts and sustainable strategies, as well as a case study. The case study is carried out in a large footwear company, data collection is made from *in-loco* visit, observation and interviews. Subsequently is conducted an analysis regarding the relation between the collected data and theoretical concepts presented.

Design, sustainability and strategy: The theory

The design's relationship to sustainability have been drawn for a while, and presented evolution over the years. Concerns about the ecological impact of industrialism dates from the 19th century, however, only in the late 1960s appeared a new approach to design related to the environment (Cardoso, 2008). An important mark of this new ideology was the Club of Rome Report, one of the first documents concerning the industrial growth problems, published in 1972. Titled *The Limits to Growth*, its contents held that:

> *[…] continued exponential growth would cause industrialized nations to lose the basis of their existence within the foreseeable future. Rapid depletion of natural resources, rising population densities, and increasing pollution would lead to destabilization or a complete collapse of industrialized societies (Bürdek, 2005, p. 58).*

The sustainable design of the 1970s was marked by harsh criticism of modern consumerism; Victor Papanek was one of the greats of that era, defending the alternative design as a form of industry boycott (Cardoso, 2008; Papanek, 1995). A second phase of the design oriented to the environment begins to be perceived in the 80s, under the concept of "Green Design". This phase involves the fight against waste, to reduce consumption of natural resources, disposables and unnecessary packaging. It also involves the reuse of products and recycling of materials, as well as the choice for certified products with ecolabels (Martirani *et al*., 2006).

From the post-modernity, issues related to sustainability associated will conscious production of new products have gained immense importance. Currently some authors (Hallstedt *et al*., 2013; Gaziulusoy *et al*., 2013; Simões *et al*., 2013; Platcheck *et al*., 2008) no more define ecodesign as an area apart from the design, but as a prerequisite to the development of any product. Following this idea, the ICSID (International Council of Societies of Industrial Design) describes and identifies the design as a technological innovation factor capable of contributing to sustainable development. In this sense, some authors (Manzini and Vezzoli, 2008; Platcheck, 2012; Niemann *et al*., 2009) point to the development of methodologies for sustainable products based on life-cycle assessment (LCA) of the products.

The life cycle of a product consists of a network of interconnected processes that composes all stages regarding a product, since its creation, manufacture, use, disposal and possible reuse (Niemann *et al*., 2009). It is known that the environmental impact of a product is determined by decisions made in the early stages of its development (McAloone and Tan, 2005). Selection of materials and processes, for example, can influence the amount of waste generated, as well as the energy consumption during production. Therefore, is discussed the need of product life cycle analysis, so that designers can act effectively reducing negative environmental impacts on each phase. To Manzini and Vezzoli (2008) the concept of product life cycle (PLC), shown in Figure 1, refers to the trades (inputs and outputs) that occur between the environment and all the processes that accompany each stage of a product's life, from the pre-design to end of life.

From it, is possible to understand the interference that the product causes in the natural environment – the so-called inputs and outputs, being the inputs all that is taken from the environment (raw materials and energy) to integrate the PLC. The outputs are all that result from the PLC and is returned to the natural environment (solid waste, fluids and gases). A complementary concept to the PLC is the reverse logistics, which means all operations related to the reuse of products and materials (Gonçalves-Dias and Teodósio, 2006).

That is, reverse logistics is the inverse of logistics flow, which part from the end of life and return to the production chain. The adoption of this reverse system is justified by a number of factors, such as competitiveness, cost reduction and reduction of the distribution channel (Rodrigues *et al*., 2002; Leite, 2009). According to Leite (2009), the vision of reverse logistics is concerned with the product project aiming the reuse in different forms, which establishes the connection between this concept and the design of sustainable products with a focus on reuse and recycling.

Advancing through new concepts, the majority of design areas understand that the development of sustainable projects do not depend on isolated factors, but on an interconnected network of actors, such as business, competitors, consumers, social and economic issues. Thus, in 1999

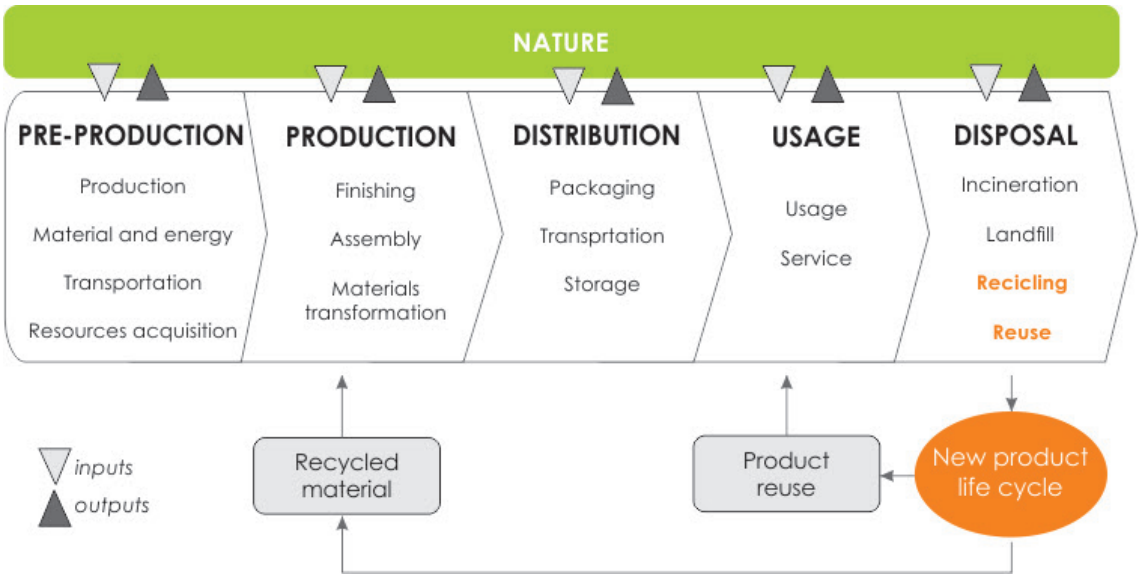

Figure 1. Product life cycle.

Source: Adapted from Manzini and Vezzoli (2008).

the author Ezio Manzini already argued the need for a profound change in industrial culture, which go through a transition of the business model driven by product (product-oriented) for a model driven by the product-service system and all its actors. This approach characterizes the strategic design, or in the case of sustainable product development, strategic design for sustainability. Strategic design can contribute to the search for sustainability through the development of eco-efficient strategies and changes in social behavior (Meroni, 2008). Manzini and Vezzoli (2003) conceptualize the strategic design for sustainability as an innovation strategy that changes the focus of the business to only develop (and sell) products, to develop (and sell) a system of products and services, that together they can meet consumer needs while reviewing unsustainable trends in production and consumption practices. Thus, the product-service system (PSS) is considered the study object of strategic design.

It should be noted that the PSS has a great potential for the development of sustainable solutions, it offers useful and promising concepts for it. However, only when the PSS operates effectively in the re-orientation of production and consumption for sustainable trends, we can speak in a product-service system for sustainability (UNEP, 2002). This approach requires changes in consumption patterns and user experience, in the companys organizational structure, as well as in regulatory and cultural issues. In other words, muti-dimensional changes of technical and socio-cultural are needed (Ceschin, 2012). Thus, the strategic design offers the possibility of achieving synergy between profit, competitiveness and environmental benefits. From this premise, it presents another concept connected to design and sustainability: the eco-innovation.

The way companies integrate environmental concerns into their strategies, strengthens the competitive advantage through eco-innovation (Marchi, 2012). According to Rennings (2000), the term environmental innovation (simplified for eco-innovation) was introduced by the interdisciplinary project called "Innovation Impacts of Environmental Policy Instruments". The term concept was defined as: all measures of relevant stakeholders (companies, politicians, associations, churches, private homes) to develop, apply or submit new ideas, behaviors, products and processes that contribute to the reduction of environmental impacts or with sustainability goals. It is therefore a multidisciplinary strategic tool for sustainable development (Rennings, 2000). This tool is able to generate competitiveness in economic markets, since environmental problems are global issues, the markets innovative solutions to this problem are to (Jänicke, 2012).

Relying on the presented strategies and concepts, product design has evolved in the development of solutions to minimize environmental impacts. Based on this literature review on the subject, it is presented a case study of a design for sustainability practical application in the footwear production, an important sector of the national economy, as shown below.

Footwear production and waste generation: Risks *versus* improvement opportunities

The leather-footwear sector represents a major share of the national economy. According to the annual report of Brazilian Association of Footwear Industries (*Associação Brasileira das Indústrias de Calçados* – Abicalçados, 2015), the Brazilian Footwear park consists of about 7.9 thousand companies, generating more than 280 thousand direct jobs. In the year of 2014 the industry produced 877 million shoes, generating a trade balance surplus of 479.4 million dollars. In contrast, the footwear production is traditionally recognized as a significant environmental impact activity, mainly due to the high volume of solid waste generated (Calandro and Campos 2015).

According to Brazilian standard ABNT NBR 10004:2004 tanned leather shavings chromium (one of the main inputs of the footwear production) are hazardous waste (classified as 1 – the most dangerous) due to its toxicity and risk of contamination. Despite the wide variety of materials for footwear production, chrome tanned leather remains one of the most traditional. In the European footwear industry, more than 70% of produced leather shoes use tanned skin chromium in leather, which inevitably generates large volumes of toxic waste (Ferreira *et al*., 2014). In this case, the disposal in landfill remains the main option in terms of management (Ferreira *et al*., 2014). However, this situation wastes material with potential for reuse, also, it generates high costs of disposal. According to Jucá (2003), the amount charged by the landfill of Porto Alegre (in the state of Rio Grande do Sul, Brazil) is the second highest in Brazil, losing only to cities in the Brazilian state of Tocantins. Thus, the cost of disposal of waste is a factor that reduces the price margin of the final product, impacting on competitiveness. Furthermore, the larger the volume of waste, the lower the available space in landfill, so the cost of disposal tends to become increasingly higher.

Despite disposal in landfill is one of the most suitable, it presents environmental risks, especially related to leachate, which can contaminate soil and water (Yabroudia *et al*, 2013; Bouzayani *et al*, 2014), generating health risk to the populations living around the landfills (Vrijheid, 2000). In this sense, finding effective ways of waste disposal, which minimize or eliminate the impact on the environment, is the current fundamental problem for industries (Alves and Barbosa, 2013). Several studies have been conducted aiming the reduction of environmental impacts caused by leather and footwear production. Among the main solutions cited in the literature, we may cite: carbon footprint analysis (Herva *et al*, 2011), recycling polymer waste generated during production (Lima *et al*., 2010), development of waste management plan (Staikos and Rahimifard, 2007a), sustainable product development based on the "cradle to cradle" system (Jaques *et al*., 2010), post-consumption waste management (Staikos and Rahimifard, 2007b), footwear development from renewable material (Cao *et al*., 2014) among others. This wide range of studies devoted to environmental issues related to footwear production, reinforces the relevance of the subject and points to possible ways. However, the current reality still shows, in general, a pollutant industrial and hazardous high toxicity waste generator that requires urgent solutions (Alves and Barbosa, 2013). In this sense, a study (Scherer *et al.*, 2009) showed that investments (from mature companies in the Brazilian footwear industry) in environmental management practices are from low and medium intensity, with some level of

commitment to the adoption of such practices that end up concentrating in basic and regulatory aspects.

The importance of reducing the environmental impacts of solid waste is not discussed only among the scientific communities. In Brazil there is a strong legal pressure to promote the management of solid waste through reverse logistics practices, eco-design and recycling – the National Policy on Solid Waste (*Política Nacional de Resíduos Sólidos – PNRS*) established by the Law 12.305/10. Among the objectives of PNRS, listed in its Article 7, we highlight the item II that defines "the non-generation, reduction, reuse, recycling and solid waste treatment and environmentally correct disposal of waste" (Brasil, 2010, translated by the author). According to Campos (2014), an important aspect of the law is the direction that the disposal in landfill is the last stage, that is, the recycling processes and materials recovery must be exhausted. Thus, this determination implies on the development of materials recovery processes that are more suitable for each type of product, while minimizing the amount destined to landfill. In this sense, Jabbour *et al*. (2014) add: the institution of PNRS can result in technological innovation opportunities, both in the social and economic areas.

In this context, the design focused on sustainability is presented as a tool to enhance sustainable development in the footwear industry. Considering the economic importance of the sector and the need for new practices to reduce negative environmental impacts, it is understood as ideal the restructuring of process development, manufacturing and consumption, facing environment without reducing the financial performance and competitiveness.

Practice: Footwear development with focus on reducing waste generation

As a practical example of the sustainable design application in the development of footwear, it is presented the case of children's shoes production in a large footwear company (production of 15 thousand pairs per day) situated in the state of Rio Grande do Sul, Brazil. At this company, the development process is conducted based on traditional factors such as trends and season, but is also considered a different factor: the volume of waste (leather scraps) generated in the prior collection production. Besides, it is also considered the volume of leather waste in smaller pieces that will be lost during the manufacturing process of the main collection. Thus, the style team is responsible for creating a unique model for reusing the leather scraps that would, otherwise, be discarded in landfills (causing a high cost, passed on to consumers in the final product price).

In the first waste reuse technique (larger pieces stored along the last collection production), the reuse begins to be planned from the footwear development (design and specifications). The designers are informed by the materials planning sector about the quantity, color and type of leather pieces that were stored. From these data it is developed a special footwear model in which all cuts and colors are defined in order to apply the maximum available leather waste, resulting in the smallest volume of waste as possible, one example is shown in Figure 2. The new shoe design defines only the leather colors to be used, but not the type (varnish, opaque, textured, etc.). Thus, there is no unity among produced footwear pairs; each pair may have different leather types. Since the approval of the models, the scraps are reintroduced into the production process as any other material.

The second technique of waste reduction involves the reuse of smaller leather pieces, which were left over from the production of the main collection. These patches are too small to cut a piece for a shoe, but can be used in small decorations and details (such as petals for the manufacture of a flower or strips for a ribbon). Following the calculations of how much primary material is needed for the production of the collection and what will be the volume and size of the generated patches, the development team creates solutions to take advantage of this material. Such solutions are usually the development of models with small details such as flowers, ribbons and ornaments, as shown in Figure 3.

This practice requires more time from the development team to create the models, as well as more time and cost from the production, considering the semi-manual cutting process (each piece is cut individually). Before the use of this technique by the company, all the details and small ornaments were cut into primary material, which led to the generation of more waste, and prevent the reuse of wasted pieces from the ornaments due to the small size. That is, in terms of cost, the spent on raw materials acquisition was higher, as well as the spent with final disposal. Regarding the reduction of solid waste generation and its impact on the environment, the adoption of the new development generated a 15% reduction in weekly waste disposal. In three weeks of production, 21 Kg of leather were reused only in one of two plants of the analyzed company.

Analysis from the perspective of design for sustainability

In the described case it is observed that the adoption of sustainable practices in product development has gen-

Figure 2. Stored leather pieces and the shoe made from leather waste.

Figure 3. Shoe details made from small patches.

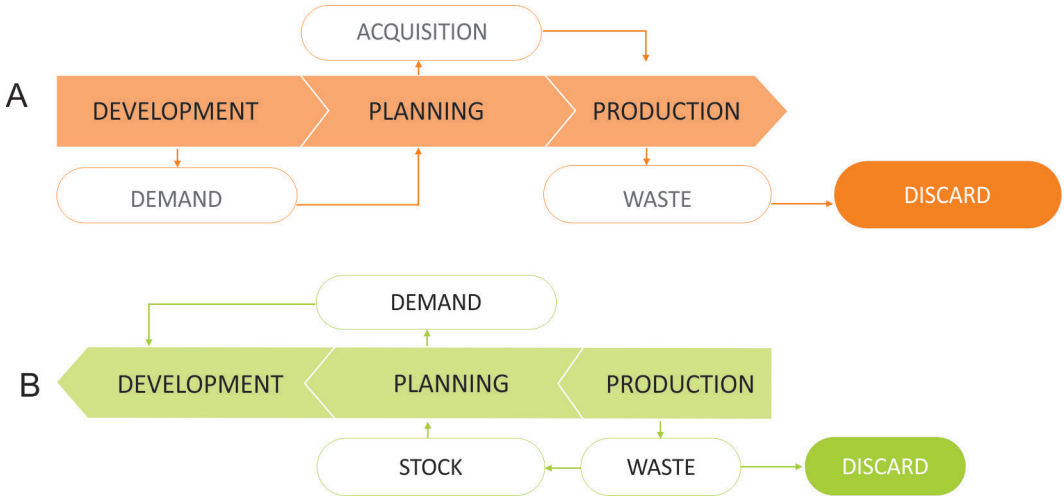

Figure 4. Process flow adopted before (A) and after (B) the implementation of sustainable practices.

erated satisfactory results in reducing waste generation. These results can be assigned to some concepts and principles from design for sustainability, which deserve a more detailed analysis, as follow.

Identification of improvement opportunities and possible solutions: The first step in the adoption of sustainable design strategies is the identification of the problem, and then attempt to visualize ways to solve it (Meroni, 2008). In the studied case, the objective was clear: to reduce the generation of leather waste and thereby reduce the environmental impact and the cost of landfill disposal. The identification of the problem occurs more efficiently if the product life cycle is deepened known. Regarding the presented case, the phases of pre-production and production showed a critical point in terms of waste generation. From this situation, came up a relatively simple alternative: the reuse. However, to organize a consolidated productive structure into a new process is not always an easy task, which leads to the second important point: the need to adapt the existing structure.

Production cycle processes restructuring: In the studied case, this restructuring consists in reversing the order of the activities from the development and planning sectors, i.e., there is the adoption of a reverse logistics flow. Instead of the traditional way in which the development team sends the information about how much material is necessary for the collection production (Figure 4A), is the planning sector that sends to the development the information about material availability for the collection creation (Figure 4B). That is, this situation creates a new design requirement and with it, a challenge for designers: the limitation on available resources, which did not existed before.

Adaptation to environmental requirements without loss of competitiveness: It should be noted that in the studied case, the adoption of strategies for reduction of waste generation required investments in some sectors, especially in the development (creation), cutting and assembly. In addition to creating the traditional collection, the team has to develop a unique model with specific requirements and constraints, as well as parts conceived for making the best use out of the available material. The production time also increases (resulting higher costs) – cutting shall be performed in each piece individually, evaluating the best position to fit the piece cut. Also, the assembly requires more time and manual labor to sew and glue the small details. This increases the costs, however, it is offset by the reduction in waste final disposal cost, since adopting the new system, there is a recovery of waste and savings on purchase of raw materials.

Conclusion

This study aimed to analyze the development and production of shoes from the perspective of design for the reduction of waste generation. It was observed that the application of sustainable design concepts and strategies, specifically in the studied case, yielded satisfactory results in terms of minimizing leather waste. Moreover, in economic terms, it was noticed that the higher cost of production is offset in the economy with the purchase of raw materials and reduction in waste disposal costs.

This way, results showed the importance of integrating environmental concerns into the studied company strategies through the connection of different areas and intern processes, such as production, planning and development. This conclusion is a good example on how the theoretic concepts of lifecycle analysis and reverse logistics may be applied on practice. The analysis showed that understanding deeply the product's life cycle was important for efficiently identify the problem and correct it. Also, to correct the problem, it was necessary to change the order of the activities from the development and planning sectors (reviewing the traditional production cycle), such as suggested by the reverse logistics flow concept.

It is important to highlight that the studied case also involves consumption trends and consumer behavior on "sustainable" products. It is known that cultural issues are another key factor to achieve synergy between profit, competitiveness and environmental benefits. Thus, the analysis of consumer behavior concerning products developed with secondary material is a proposal for future work to deepen the results from this study. Thus, this research presents a

contribution to the study of sustainable design as a holistic approach, dependent of different actors from varied areas to achieve a positive result in terms of environmental impact minimization without competitiveness loss.

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