

SUSTAINABLE DESIGN APPLIED TO RESIDUAL ANIMAL LEATHER FROM THE FOOTWEAR INDUSTRY.

MEIRE OLIVEIRA¹, BERNARDETE SOARES², ANA CRISTINA BROEGA³

¹ University of Minho, meiredesigner@hotmail.com

² University of Minho, bernardetesoaressapo.pt

³ University of Minho, cbroega@det.uminho.pt

Abstract: *This article relates design concept under the Ecodesign from the important environmental issues threatened under the constant production of waste during the excessive production of the current industry, focusing specifically on the problem and great question of waste generated by the footwear industry. Leading this way, to seeking for solutions based on sustainable design with principles connected to slow design. Subsequently, this research focuses on the reuse of leather waste within a footwear company in study attempting to convert it in fashion products and sustainable interior design objects. The result suggests reveal slower processes in their differential production system integrated into the upcycling concept as well as the technical contribution of the modular design, which essentially aim at minimizing the resources and production processes and the optimization of its lifetime.*

Key Words: *Sustainability, waste leather, upcycling, slow design, modular design.*

1. Introduction

Nowadays, the volume of waste and pollution generated in the environment is increasing intensively, produced in such a way that it becomes impossible to be absorbed by nature (Salcedo, 2014). Faced with this reality, we are witnessing the creation and development of organizations with sustainability-oriented strategies. According to the Intergovernmental Panel on Climate Change (IPCC), in many industrialized countries it has been implemented, regarding to the waste management, a policy of waste minimization and the valorisation of the 3 Rs - Reduce, Reuse and Recycle. This implementation has the purpose to reduce or eliminate solid waste deposited in the environment, aiming to contribute to achieve a sustainable development model, which is structured according to the social, economic and ecological components (Ballen, 2005 apud Santos, 2015).

Industrial waste originating in the sector of leather goods are one of the most responsible for damage to the environment, because these are considered solid waste of Class 1 - high toxicity in the environment, deposited on the environment during manufacture of leather goods (Ferreira, 2012).

In today's society there is a growing level of consumption that accompanies the increasing level of demands from consumers looking for products able to satisfy their ambitions for the quality of life. However, this consumption is, directly or indirectly, one of the main factors responsible for the pollution and depletion of natural resources. Therefore, the biggest challenge for leather industries applied to the footwear is to find effective measures regarding the deposit of solid waste, to minimize or eliminate the negative impact on the environment (PNGR, 2011).

Given this reality the concept of eco-design provides an excellent opportunity to reduce the negative environmental impacts associated with the products and processes and could lead to more sustainable relations between the ecological and economic systems (Papanek, 1985; Manzini & Vezzoli, 2008).

Due to the high rate of toxicity present on leather, the principle of upcycling is what has currently highlighted under the eco-efficiency of ecodesign as an alternative to the process of reintegration this type of waste in the life cycle of new materials or products with better quality and environmental added value.

Given these facts and the opportunity of the leather waste reutilization within a company, this article deals with the problem of waste generated by mass production of the footwear industry, with emphasis on searching for solutions leading to the development of new sustainable products. It is used an approach under the ecodesign through upcycling principle and modular design method applied on clean solid waste (leather), to create small geometric patterns surfaces bi-dimensional and three-dimensional and can be applied in a range of existing products within the company and/or other market segments such as utilities accessories, interior decoration. In this way it is intended to present two proposals for a more environmentally friendlier products focused on distinct segments market, based on footwear design upcycled through processes and resources in a particular shoe industry and a ceiling *luminaire* developed by the modular design method without mechanical or manual sewing aid. The projetual design method has its starting point in the reuse of clean waste materials purchased in a given shoe industry located in northern Portugal. These proposals aim to promote the reintegration process of waste materials in order to prolong the useful life of the product with the least possible processes and energy resources.

1.1 Valuation of waste in the footwear industry

During the last decades, the footwear industry has adopted different techniques and methodologies regarding the minimization and recovering the waste generated during production of footwear, however inevitably there is the constant formation of waste, essentially the raw material, particularly residual leather.

In Europe, the footwear industry observe almost about 70% of animal leather residues wasted, that is, tanned animal leather with chrome residues are deposited in landfills for industrial waste, sometimes considered through more sustainable approaches a potential by product for a future reintroduction into the production system (Ferreira, 2012). This waste of raw materials originated from the different manufacturing operations from the upper and the lower part of shoes, consisting of small flaps, parings, sawdust, chaff and residual leather powder and soles milling.

In Portugal, from the 90s, there were implemented several waste management strategies, such as the Strategic Plan for Municipal Solid Waste (SPMSW) and the Strategic Plan for Industrial Waste Management (SPIWM) (PNGR, 2011). For the authors Papanek (1985), Manzini and Vezzoli (2008) the minimization and valorisation of waste is a urgent topic to be considered, since it allows, for a particular product or service, the interaction by industries in order to improve in all different stages of production the kinds of resources and reduce energy consumption and materials. One of the essential phases and that can make the most difference in the valorisation of waste is the initial phase of projecting new products which consists of the selection of secondary raw materials with the primary purpose of reintroducing the wastes in the production system earning in this way increased value.

One of the main ways to initial study to reduce these aspects and negative impacts and to strengthen the prevention of wastes generated from this industrial sector is the introduction of an approach that considers the entire life cycle of products and materials, from extraction of raw material, production and use, to management and waste disposal. Since the environmental effects come from interrelated decisions in achieving the various stages of the product life cycle (AEP, 2013).

Therefore, It is from the base tool of Life Cycle Analysis (LCA) that it can evaluate the multiple impacts of a product throughout its life cycle. Thus, this analysis can be used to identify and control the most important environmental aspects; it may also designate a baseline for comparison of processes and products, allowing to define the objectives of sustainability, and finally communicate product improvements or the changes needed to solve an imminent problem (Salcedo, 2014). Starting from this basic principle, the implementation of the LCA method in the fashion industry promotes useful as the base selection of possible appropriate solutions meeting the demand for a more sustainable path (Papanek, 1985).

In an analytical and continuous thought, Soares (2015) made an approach to Life Cycle Analysis inserted within a certain footwear company, as well as a possible recovery of leather clean wastes. The PLC analysis

allowed outline an attempt to determine the reintroduction of clean solid waste generated in the production, observing all conventional stages of fashion footwear process of production, from design to the product modelling, the planning and material selection, raw material cutting, sewing, assembling, finishing to final product distribution. In this way it was perceived that ecological or environmental issues must be considered at every stage of the Product Life Cycle (PLC), identifying therefore pollution levels generated at each stage of the product life, from its design to its disposal, as I approach the authors Papanek (1985), and Manzini & Vezzoli (2008).

The study of Soares (2015), allowed the data processing provided by the Portuguese company in relation to solid waste generated annually. First, the observation data showed that solid waste is generally composed of raw materials of animal origin, synthetic materials and components of footwear, with the most relevant quantity for the waste of raw material (leather and fine leathers from liners) and less on the synthetic disposal materials and footwear components, as presented by the company in study and in Figure 1.

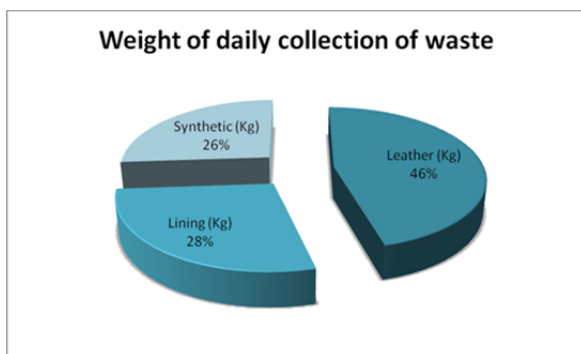


Figure 1: Analysis of daily collection of different types of clean waste generated during production within the company
Source: authors

From the data collected it is possible to verify the problem in the generation of waste within in the environment, once it is more than 100 tons annual discarded to landfill, (besides environmental pollution due to its transportation) and in addition to the loss in the economic and financial within the company, which annually are dispensed thousands of euros because of this.

The recognition of the amount and the residual leather type generated during the production of footwear in this company has identified as one opportunity in the exploration and depuration of these materials to create sustainable design solutions targeted to the areas of fashion accessories and interior decoration. However, due to the high present toxicity index of the leather, one of the most ecological solutions focuses on upcycling process for the reuse of clean residual skin generated by the company in question, giving the possibility to re-enter in a new cycle of production from resources and processes of low environmental negative impact.

1.2 Upcycling applied to the valuation of clean solid waste

As a result of mass production of the fashion industry and the generation of waste underlying the upcycling principle are what currently has highlighted the development of more sustainable products in the design area. Its method defined as reprocessing or reuse of materials, i.e., return waste in the product life cycle from the design process, and opening opportunities for new market segments.

In the footwear industry, many of the discarded waste are potential raw materials that can be reintroduced into the production chain, becoming a new material or product. These wastes can be classified by three distinct stages: post-consumer - waste created at the end of use of the product, pre-consumer - waste products not consumed by the market, and production - waste generated in the production chain of the product (considered scraps and clean cuttings).

In pre-consumption, selected materials are cleaned, identified and classified in order to obtain a process of reuse or recycling quality. Pre-consumer materials may be waste and by products of a particular production cycle or waste and surplus generated externally to the original production process (Papanek, 1985). This production model opens up to global and local economic growth, from the concept of upcycling for creating products with environmental value added (Braungart & MacDonough, 2013).

The production process in the shoe industry is characterized by its discontinuity, with the production flow occurring between five distinct stages: design (modelling), cutting, sewing, assembly and finishing. In each of these steps, the operations performed are also divided into several stages according to the type of footwear produced and the size and structure of the company. The reject untapped in the cutting phase is considered a clean solid waste in potential and is also the one with better performance in relation to its reuse in the product system (Soares, et al., 2015). The reintegration of these wastes can occur through the approach of ecodesign and upcycling principle in Production Life Cycle - PLC with this reintegration already defined and planned from the early stages of the product system.

Along with these principles, the approach of upcycling concept coupled with the slow design principal have been providing some beneficial contributions to the reuse of clean waste centred on reducing resource processes and consumption of materials and services. The slow design works as a set of principles and slower processes of production, focusing on the attraction of consumption for sustainable development, thus reducing their environmental, industrial and economic impact. This set of actions provides a close relationship and view from the designer with the consumer, allowing an affective consumption relationship through the product concession with ecological value added and reduction of potential impacts in the future.

2. Sustainable Design

In the field of sustainable design, eco-efficiency is widely used as a strategy for addressing the environmental aspects. Its main focus is to create products and services with less and less use of resources, waste and pollution (Manzini, 2008). As part of this strategy, one of the approaches where design and designers portray their responsibility dimension is the Ecodesign (Vezzoli, 2010), through reduced environmental impact of products by encouraging the creation of new opportunities for the industry, taking the first progressive steps towards sustainability. In this context, the potential role of designers within the sustainability and its outstanding contributions beginning to show their important mark to a more sustainable world (Papanek, 1985; Manzini & Vezzoli, 2008), mainly in order to find solutions that present environmental quality and which does not renounce at all the social and cultural quality.

In this context, many designers and companies are seeking to integrate in their products, concepts and sustainable design principles, either by level of processes choice in which it operates, or by references of material and cultural or of which they are part. These methods used in the production process may vary depending on the size of the company and the market to which it occurs (Gwilt, 2014). The interdependence of the factors involved in the development of a sustainable product is essential for a positive outcome of a project, supported by the Ecodesign, which integrates its methodology to design concepts to meet the needs of the environment. The result of this integration can be characterized not only by the environmental value addition, but also for its functional, aesthetic and emotional aspects, with future projections (Braungart & McDonough, 2013).

2.1 Modular design applied to clean waste

One of the relevant requirements for the production of sustainable products relates to the easiness of assembly and disassembly of these and can be directly connected to the extension of the product life, since it facilitates the maintenance, the repairing, upgrading and re-manufacturing (Manzini & Vezzoli, 2008). In this way, among the methods of projecting applied in design stands out the concept of modular design used to create patterns of two- and three-dimensional surfaces and contributes to the development of new modular products, associated with reuse of materials, generally flexible bases and multi-conjugable, to propose versatility, customization and affectivity to the user.

The modular design method consists in organizing a number of small regular or irregular modules through a mathematical support that can be developed independently and which subsequently may be interconnected to generate various other underlying modular pattern, giving rise to the composition of new visual forms based on the concept "do-it-yourself" (Santos, et al. 2015). This system of modular standards allows it to be organized in order to make an item in a number of other projects without a single industrial or manual sewing.

This method defines the concept of "minimum and maximum stock of diversity", subdivided into a number of units with standardized modules may be independent or combined in a variety of configurations to carry various functions or create different structural forms (Pearce, 1990; apud Hur & Thomas, 2011). The modular design technique is applied in redefining materials through upcycling principle and the process of production of Slow Design, since it relates the various individual and collective needs in harmony with the needs environmental and socio-cultural, in order not to focus only on the excessive production of products that define and characterize the overall brand positioning in the highly globalized current market. Try to avoid so its management according to time constraints and economic growth (Strauss & Fuad-Luke, 2008).

3. Analysis and Empirical Development

Based on the considerations presented in previous topics, the present article research methodology is classified first as an exploratory research using the a case study method, thus enabling the direct contact with the problem to be researched from observations and deep perceptions, with constant access to informality and creativity.

Faced with this methodology we used the exploratory procedure that in the best way fits the work-study, based primarily on projetual processes of design, based mainly on the design of projective processes influenced in the approach of reintroduction of clean waste in production lifecycle (PLC), from the development of sustainable products with the constant reuse of waste leather of the footwear industry. The approach of ecodesign and upcycling with the inclusion of the integrated modular design method was adopted in the process of slow design for the discarded leather conversion into new products, with constant environmental concern. The selection and characterization of waste (residual animal leather) develops within the footwear company under study, located in northern Portugal.

The procedure begins with the daily separation of the residue of the raw material in the company, among leather and lining, residual synthetic textile materials, fabrics and synthetic fibers for subsequent weighing each individual type of waste. After this process it was possible a detailed observation of the amount of types waste material. There was quite distinguishing the large amount of leather waste, and little difference between residue leather lining and synthetic material (figure 2).



Figure 2: Daily collection of clean waste inside the company and its careful separation for further data processing. **Source:** authors

The identification of the cleaned waste took place during the different stages of shoe production, but especially in the stage of cutting raw material and synthetic material, considering the animal leather wasted an opportunity for the reutilization of the Product Life Cycle system (PLC).

The upcycling and modular design method aircraft were projected for primary stage of creation of possible new sustainable products. It was used small geometrical modules residual leather to the development of two independent patterns surfaces. The first pattern consists of small squares - 25 cm² each, joined with the help of industrial sewing and the second consists of small rectangles - 50 cm² each, joined by fittings, without industrial or manual stitching feature for joining the parts. Both proposals have the production process feature of the principle slow design, enhancing the emotional attachment and long durability, the products were respectively directed to the areas of fashion accessories and interior decoration.

4. Results

Rethinking in the broadest sense of sustainability in the shoe industry, joining the initially formed ideas and applied in the creation of surfaces "upcycled" and the modular design allowed the projection of some more environmentally friendly products during the production of products main line of the company targeted and other market segments, reusing leather waste.

The first proposed solution consists of in designing an average boot high heels, with the residual skin surface created from the quadrangular modules along with the residual leather reused in the frontlet (forefoot) thereby forming the ecological upper of the boot. It was performed a preliminary calculating of the number of modules appropriate to different patterns constituting the upper. The development of surface pattern "upcycled" has 60 modules quadrangular mechanically sewn together. The seam "upcycled" surface is the external seam, leaving visible the edges to the outside surface (crest seam), which reveals a volume and a differential aesthetics of the upper of the boot. It was developed technical drawing of the boot, which can be seen in Figure 3, along with the prototype.



Figure 3: final technical drawing and Boot prototype, "upcycled" residual skin. **Source:** authors

The second proposed solution is to design a modular structure applied to the luminaire for interior decoration. The luminaire corresponds to a modular design area of 50 cm², with multiple patterns composed of regular hexagons 8 polygons residual bovine leather, totalising approximately 192 modules. It was used the system interconnect type plug-in segments of small geometric modules of craft production in the process of assembly and disassembly without using the manual or industrial sewing or even an auxiliary component. Figure 4 shows the illustrative drawing and the prototype of the luminaire.



Figure 4: Illustrative drawn and final prototype 3D (modular standard residual leather) applied to the luminaire. **Source:** authors

This process besides contributing to manual assembly and disassembly of the modules facilitates also the replacement, the reorganization and reuse of each modular part, avoiding the needs of energy resources supplies and minimizing impacts on the environment.

All these methods and resources in the conception of the modular design and upcycled portray the sustainable potential of production and processes through the reuse of animal leather waste. Although sustainable design of these products involves investment production processes with slower flow. On the other hand, it opens a window of opportunity for socializing between local companies and cooperative entities, aiming to optimize the flow production process, energy resource and environmental negative impact.

5. Final considerations and future perspectives

Industrial waste in the sector of leather goods are considered one of the most responsible for damage to the environment, since they are solid waste with a high level of toxicity in the environment, deposited in the environment during manufacturing and production of leather goods.

Regarding footwear industry, different techniques and methodologies have been developed within the framework of minimization and recovery of waste generated during production, although a problematic question inevitably comes up with the constant presence of residues of raw materials such as leather residual.

Given this current reality, the project here elaborate responds in some way to reduce the disposal of these wastes from footwear industries, thereby contributing to the creation of new products able to extend its lifetime and its reused of raw materials, from its modularity and the reuse of residual animal leather. These concepts developed through upcycling methods and modular design, demonstrate an unconventional production and essentially differential with ecological value added in manufacturing fashion accessories as well as interior decoration accessories, respecting a slower production within the principles of slow design and answering to a more conscious consumption within the fashion.

Under a subsequent perspective, the exploitation of this project through innovative social application is looking for the future development, thereby enabling the introduction of new solutions face of persistent problems of the industry, through interrelations in inside of the society, including collaboration, associations, organizations, etc. Thus arises the attempt of a design project rethinking focused on the social context, taking into account creative and productive actions of slow design for the development of new products that promote well-being in society, trying equally respecting the ecological limits on the environment.

Acknowledgements

The authors of this paper thank the P.C.F. Footwear Production Company from Felgueiras and AIREV Association of Vizela for the opportunity to develop this project.

This work is financed by FEDER funds through the Competitiveness Operational Programme - COMPETE and by national funds through FCT – Foundation for Science and Technology within the scope of the project POCI-01-0145-FEDER-007136



References

AEP. 2013. *Certificação Ambiental...por um crescimento econômico mais sustentável - Manual Prático de Eco-design*. Portugal: Câmara de Comércio e Indústria.

- BALLEN, H. M. V., 2005. <https://books.google.pt>. [Online] Available at: <https://books.google.pt/books?id=FhqHCgAAQBAJ&dq=o+conceito+de+sustentabilidade+apresenta+cinco+dimens%C3%B5es:+social,+econ%C3%B4mica,+ecol%C3%B3gica,+geogr%C3%A1fica+e+cultural.&hl=pt-BR> [Acesso em 4 abril 2015].
- Braungart, M., & McDonough, W. 2013. *Cradle to Cradle - Criar e reciclar ilimitadamente* (1ª ed.). (F. Bonaldo, Trad.) São Paulo: Editorial Gustavo Gili.
- Ferreira, M. J. 2012. *Contribuições para a Gestão de resíduos de Couro Curtido com Crómio da indústria do Calçado*. Portugal: QREN 2007-2013. GV
- Gwilt, A. 2014. *Moda Sustentável*. Barcelona: Gustavo Gili.
- Hur, E. S. & Thomas, B. G., 2011. Transformative Modular Textile Design. *School of Design, University of Leeds*.
- Manzini, E. 2008. *Design para a inovação social e sustentabilidade: comunidades criativas, organizações colaborativas e novas redes projetuais*. Série Caderno do Grupo de Altos Estudos do PEP/UFRJ ed. Rio de Janeiro: E-papers Ltda.
- Manzini, E., & Vezzoli, C. 2008. *O desenvolvimento de produtos sustentáveis: os requisitos ambientais dos produtos industriais*, EDUSP/ Ed. São Paulo: Universidade de São Paulo.
- Papanek, V. 1985. *Design for the real world: human ecology and social change*. Chicago: Academy Chicago Publisher.
- Pearce, P. 1990. *Structure in Nature is a Strategy for Design*. MIT Press.
- PNGR, 2011. *Plano Nacional de Gestão de Resíduos 2011-2020*, Lisboa: s.n.
- Salcedo, E. 2014. *Moda ética para um futuro sustentável*. (D. Fracalossi, Trad.) Barcelona: Editorial Gustavo Gili.
- Santos, M. O. 2015. *Sustentabilidade no Design: uma abordagem aos resíduos limpos das indústrias do calçado*. Dissertação de mestrado, Universidade do Minho, Portugal.
- Santos, M. O., Martins, E. F. & Broega, A. C., 2015. *Design Modular: solução sustentável aplicada aos resíduos limpos na indústria do calçado*. *Anais 11º Colóquio de Moda - 8ª Edição Internacional*.
- Soares, B. O. 2015. "Da Moda ao Resíduo e do Resíduo à Moda" - Um contributo sustentável no uso da pele residual na Indústria do calçado. Dissertação de mestrado, Universidade do Minho, Portugal.
- Soares, B. O., Santos, M. O. & Broega, A. C., 2015. *Modular Design: Contribution to Sustainable Development within Ecodesign and Upcycling*. Viana do Castelo, 3rd International Conference.
- Strauss, C., & Fuad-Luke, A. (2008). *The Slow Design Principles: A new interrogative and reflexive tool for design research and practice*. Changing the change.
- Vezzoli, C., 2010. *Design de Sistema para a Sustentabilidade*. Salvador, Edufba.