

## IMPROVING THE CIRCULAR ECONOMY IN THE FOOTWEAR INDUSTRY

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### Abstract

*The article presents a circular economy proposal as a way to promote greater sustainability in the footwear industry. As part of the work, we analysed the essential components for a shoe and the materials used in the production of footwear. Currently, new proposals have emerged for footwear that use materials derived from waste and the forwarding of specific end-of-life products. These new concepts are associated with added value and targeted marketing towards sectors of society more concerned with the industry's environmental impact. This reinforces the interest in the positioning of the footwear industry in relation to the circular economy. The purpose of this article focuses on the last phase of the circular economy – recycling, educating, and valuing the role of the consumer through the collection, treatment and forwarding of used footwear materials with the aim of reducing waste in landfills but simultaneously increasing awareness of the footwear industry.*

**Keywords:** *footwear industry, sustainable materials, life cycle, circular economy.*

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### Introduction

The footwear protects the feet from contact with the floor and the environment. With the development of hunting and agriculture, humans began to create foot protection for their daily life. From prehistory to contemporary age, footwear has undergone many changes, from the materials, models and objectives intended for its use. Currently, there is a wide variety of styles of footwear, which in turn represent the variable taste of the various types of target audience and the mass productivity carried out by the footwear industry. Productive massification has gradually created an environmental concern and, in the 21<sup>st</sup> century, industries, such as the footwear industry, want to be sustainable in their production. Today, in any production, the life cycle of the product is analyzed, to minimize energy consumption, manufacturing times and materials and thus reduce the impact on the environment. Companies undertake to quantitatively evaluate the environmental impacts of products, from the extraction or processing of raw materials or even natural resources, production, transport and use to the final destination of products, facilitating the assessment of potential environmental impacts on natural resources, the environment and the health of the population [1].

In an evaluation of a production of shoes [2] it was proven that in the five phases of the product life cycle, the most polluting phases were that of matter and production, from which the authors themselves, Cheah et al. [3], state that if the number of materials and number of components of a footwear were reduced, their impact values would decrease by up to 24%.

To this end, this article presents the components, production process and materials used to produce footwear.

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The productions were primarily known for the use of skins which made the product have durability, flexibility, permeability to air and water, temperature regulation, moisture absorption and ease of maintenance [4]. The hides used in the cutting part came from bovine animals, goats, sheep, pigs and reptiles. What were mostly sustainable materials, performing a circular economy derived from animal by-products, from the slaughter of the same to obtain meat, but the concerns of humanity in the face of animal slaughters created some controversy and then synthetic skins were developed to first contain the same properties of natural hides and second to correspond to the high demand that existed created by the producing companies, but as a disadvantage these materials are more polluting due to their production.

The goal will be to present more sustainable solutions through the use of biodegradable and vegan materials or new material reuse solutions such as Portuguese companies *Verney* [5] that reuse used clothing; (a) *Re-Coffe* reuses coffee grounds [6, 7]; “*As Portuguesas*”, in turn, uses cork on the soles; and *Zéta* uses corn and plastic residues found in the sea [8]. These are some examples of Portuguese brands that are categorized as sustainable and vegan due to their concerns about the environment.

In order to support the circular economy in the footwear industry with this work, an action proposal is made, in order to highlight the potential of the circular economy. The analysis will be carried out in the post-consumer recycling phase, in the creation of collection and reuse of materials in the manufacture of new products with added value.

## Shoe Components and Productive Process

Footwear is a product that can be used for different purposes, from sportier, casual to classic use, including the use of synthetic materials or natural, such as animal skins. According to the purpose of wearing the footwear, the material and design are suitable. To better understand the materials used in footwear, the components and their functions will then be presented (Fig. 1).

Due to the variety of components of footwear, many actions are performed for its production. It was analyzed a linear production company in Portugal, which is dedicated to the activity of production of comfortable footwear. It can be confirmed that for the complete production of footwear it is necessary to have four areas/sectors of production.

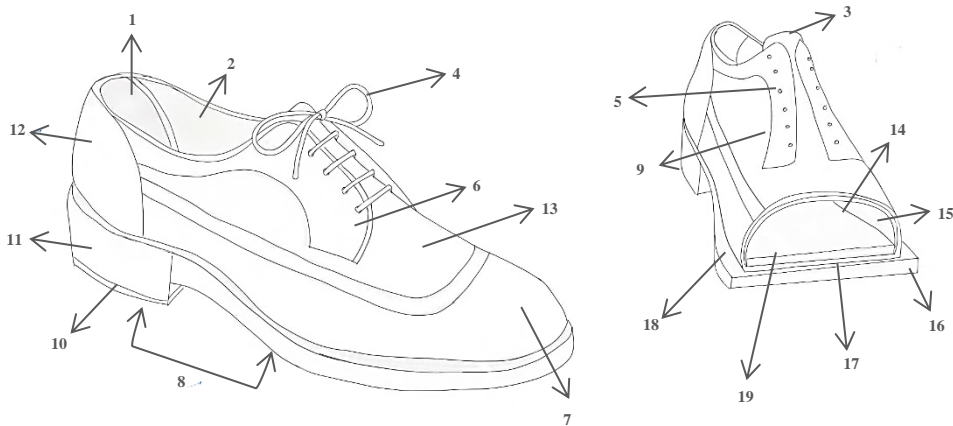
The production process begins in the cutting sector where vamps, insoles and liners are materialized. Materials such as skins, acrylics, cork, among others are evaluated to avoid production in areas with defects. Later the cut is carried out on the material, which in this case, the company has the option of two cutting methods: the oldest process, manual cutting, which is carried out through a pressure with mold on the material; and automatic cutting, which in turn, is a more recent process due to the use of equipment with scanner systems for reading materials and integrating systems with automatic knife cutting or waterjet cutting machines.

The second sector, which follows the cutting sector, is the sewing sector, also known as confection. This sector is the one that has the most processes, here the parts are phased, glued, sewn, stamped, hydraulically molded to acquire the desired shape, and finally, vamps molded to the insoles.

The component sector is where insoles and soles are created, in this company materials such as EVA (latex), polyurethane and TR (thermoplastic rubber) are used. The production process is carried out by liquid or grain injection machines, equipped with their design molds.

Finally, the assembly sector is where the finished parts in the sewing sector are glued to the insoles and soles produced in the components sector. In this sector footwear takes shape where it is finally evaluated and packaged for the customer.

During all these production processes the company makes the most of the materials to avoid waste, in the event of waste, these are forwarded, demonstrating concern with waste and complying with quality certifications and contributing to a good image before consumers.



**Legend:**

- 1 **Buttress**- Reinforcement placed between the rear and the lining in the heel region. It has the purpose of swearing the heel of the footwear, assisting in the fixation of the foot when walking.
- 2 **Tongue**- Upper part of the vamp, whose function is to protect the foot from the lace.
- 3 **Lining**- Function of providing internal finishing to footwear, reinforcement, moisture absorption and comfort, among other purposes.
- 4 **Cord**- Assists the fixation of the shoes on the foot.
- 5 **Eyelet**- Perforations made for the passage of cords.
- 6 **Eyestay**- Where the eyelets are placed to insert the cord or lace.
- 7 **Toe cap**- Piece that covers the nozzle of the shoe, gives finish and increases the durability of the pair.
- 8 **Sole**- It sustains the plant of the foot and gives firmness.
- 9 **Quarter**- Side of the vamp.
- 10 **Heel piece**- Lower art of the heel and has the function to protect the heel from wear suffered by friction with the ground and, at the same time, absorb the impact during walking.
- 11 **Heel**- Used to give height and support to footwear.
- 12 **Counter, Heelcap, Stiffener**- Part behind the leather, close to the heel.
- 13 **Vamp**- Front of shoe leather. It comprises the part that covers from the toes to the foot and can be included or composed of another piece, the toe cap.
- 14 **Finishing Insole**- Combinations with foams and other damping materials.
- 15 **Lining**- Coating used with the function of providing internal finishing to footwear, reinforcement, moisture absorption and comfort, among other purposes.
- 16 **Sole**- Function of protecting the underside of the foot, being in direct contact with the ground. It is produced in various types of materials and shapes, which provide you with different properties such as lightness, durability, flexibility and adhesion to soil absorption.
- 17 **Midsole**- Ask between the sole and the shoe mounting insole. It has aesthetic function, because it allows the oil to become thicker, without proportionally increasing its weight. In addition, it offers comfort through impact cushioning. Its most intense use is in tennis models, with various shapes, appearances, and colors.
- 18 **Welt**- Function is aesthetic, as it provides a better finish. It is supplied in various shapes and aspects, which vary depending on the model of the footwear.
- 19 **Mounting Insole, Bottom filler**- Its purpose is to fix the cut after assembly, maintaining the shape of the surface of the sole of the foot.

Fig. 1. Shoe anatomy. Adapted from [9]

**Materials and Brands**

The components of the footwear can be grouped into two parts, the part of the sole, with the sole, the midsole, the possible toe cap, the insoles and the heel; and the part of the court, consisting of the remaining parts. In the cutting part is mostly used materials such as leathers and textile fibers, while on the sole part each component has a specific material according to the properties necessary for the function of this component. In the toe cap are used materials such as steel, aluminum, or composite materials; rubber, thermoplastic rubber (TR), ethylene vinyl acetate (EVA), poly (vinyl chlorine) (PVC) and thermoplastic polyurethane (TPU) are the most suitable materials; finally, the use of thermoplastic rubber or polyurethane (TPU) is more common.

Depending on the materials the characteristics that define the functions of the footwear are different, as can be seen in Table 1, presenting the origin (natural or synthetic), organoleptic properties and derivation (whether it is new material being used or if it is a reused material from another production).

**Table 1.** Classification of several materials used in manufacturing of footwear. Adapted from [10 to 14]

Materials	Origin	Organoleptic properties	Derivation
<b>Textile fibers</b>	Natural and synthetic	Flexible; Durable; Resistant; Light <sup>[10, 11]</sup>	New material or reused material
<b>Leather</b>	Natural or synthetic	Flexible; Durable; Resistant; Light <sup>[10]</sup> ; Impermeable <sup>[12]</sup>	Reused material
<b>Cork</b>	Natural	Slow combustion; Resistance to friction; Thermal insulator; Impermeable; Lightweight; Elastic and compressible <sup>[12]</sup>	New material or reused material
<b>Steel</b>	Natural	Heat and cold insulation; Resistance to Impact and compression <sup>[13]</sup>	New material
<b>Aluminum</b>	Natural	Heat and cold insulation; Resistance to Impact and compression <sup>[13]</sup>	New material
<b>Rubber</b>	Natural or synthetic	Elasticity and traction in rupture; Easy abrasion and gluing <sup>[14]</sup>	New material or reused material
<b>TR</b>	Synthetic	Flexibility and total recycling <sup>[14]</sup>	New material or reused material
<b>EVA</b>	Synthetic	Easy pigmentation and lightness <sup>[14]</sup>	New material
<b>PVC</b>	Synthetic	Good uptake, Isolation and Antiskid <sup>[14]</sup>	New material or reused material

Although these materials are the most common in the footwear industry, two new categories of materials for footwear emerged: biodegradable materials consisting of vegetable fibers (cotton, gasket, flax, bamboo, coconut, hemp, cork, sisal, natural rubber and soy), biopolymers (Polylactic acid (PLA), Polyhydroxyalkanoates (PHA), Homopolyamides and Copolyamides (Bio-PA), Bio resin and biodegradable thermoplastic bioplastics compounds (APINAT<sup>TM</sup>), animal fiber (leather or suede and wool); and vegan materials consisting of synthetic fibers (acrylic or polyacrylic, loric, microfiber, satin or rayon, elastane or spandex, organza, polyester or tergal, nylon, synthetic velvet, synthetic suede, synthetic leather and synthetic hair) [15].

In addition to these new materials, new proposals have emerged in the footwear industry, proposals that incorporate the reuse of materials from other industries. In 2017, it was analyzed that it is possible to produce synthetic rubber composites with beer drecche (residue from the brewing industry) without fiber treatment; with and without pre-grinding; and with pre-treatment of fibers with different organza's, proving the reuse of waste from a food industry for a new production of footwear [16]. In 2021, the same type of procedure is performed, this time with coffee grounds, the brand *Re-coffe*, a Portuguese brand, used for each pair of sneakers: for the interior, coconut fiber; for insole, recycled polyurethane; and, for the sole, 30% of coffee grounds (33 coffee grounds expressed) and 70% recycled rubber [7]. The new materials, in addition to reflecting an action for a circular economy, also demonstrate the use of sustainable materials that the footwear industry has implemented in its new productions.

In the case of the Portuguese sector, which currently operates in the missive to save the planet, with a more sustainable production than through the Action Plan for Sustainability in the Footwear Row already has 50 greener initiatives that make the country internationally recognized in the development of sustainable solutions [17] the recognitions are due to productions of innovators, such as:

Re-Coffe, a sustainable vegan brand that reuses coffee grounds in the production of its soles, which in turn creates a unique smell in your shoes [7];

Zouri, an eco-vegan brand, uses plastics found on the portuguese seacoast along with ecological and sustainable materials, such as cotton, pinatex and natural rubber [18];

“*As Portuguesas*”, a sustainable brand with the world's first production of cork slippers, is brand uses cork in its sole [19];

Ways, an ethical tennis brand for conscientious consumers, uses biodegradable and recycled materials such as leather, plastics found in the sea, recycled rubber, latex insoles, linen and wool fiber and wood [20];

Nae vegan shoes, a sustainable and vegan brand, wears in its shoes pinatex, organic cotton, cork, vegan leather, apple skin, recycled pet and corn [21];

Verney, creates sustainable shoes that from the use of apple, hemp, recycled plastic bottles, recycled clothes, etc. And not the use of materials of animal origin [5];

Balutta, a luxury vegan and sustainable footwear brand [22];

Lemon jelly, a sustainable vegan brand, recognized for its lemon smell is a brand that supports the closing of the Loop by reusing its production waste and collecting and reusing its shoes in new productions [23];

Tentoes, is a sneaker brand made of materials such as leather, recycled bottles, organic cotton laces, PU insole with natural fibers and recycled rubber [24];

Hirundo, uses organic and sustainable, cork, leather, cotton and recycled rubber in the productions of the brand [25];

Zeta, a recycled tennis brand that uses grape pomace, plastic found in the sea, cork, recycled rubber, and corn in its productions [8].

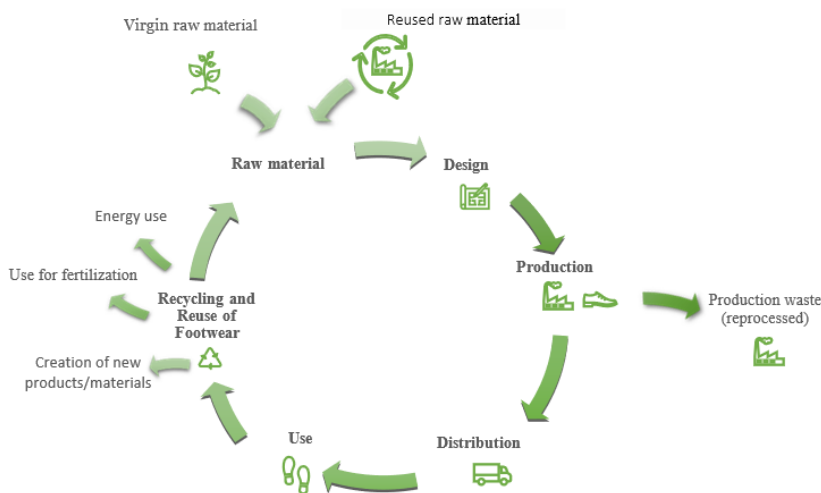
These are some examples of brands that care about the environment, animals, and their productions, creating differentiated products in the market with the use of new materials and reused materials, but that do not fail to follow the objective of aesthetics and comfort associated with footwear.

Many of these Portuguese brands in addition to selling unique and quality products have the concept of slow fashion working for the benefit of time products.

In agreement and in favor of the evolution of the footwear industry to a circular system arises the investment proposal in the recycling phase of the product with the objective of reusing materials and components from the use of means of technological metabolisms. The transition to more sustainable waste management will not be exactly easy, but with the creation of new ideas that stimulate design solutions for the implementation of circularity [26] and the creation of sustainable jobs as a solution to environmental problems and innovation for society [27].

### **Proposal**

The proposal aims to explore the possibility of creating an exclusive recycling point for footwear, in accordance with the international policies of the Circular Economy Action Plan (PAEC). Based on the valorization of productive circularity and the creation of more sustainable productions, the idea of creating an industry for the recirculation of post-use footwear emerges (Fig. 2). From the refining of the seven phases of the circular economy (Raw materials; Design; Production and reproduction; Distribution; Use of consumption, reuse and repair; Collection; Recycling), it is found that the last phase, recycling, is the most crucial, is the one that over time has had less updates and most of the action generated is the deposit of footwear used in landfills, in some countries there is already the possibility of resale and in some places collection points of used footwear. However, this is a phase that has dependency above all on the action of people and society. Then comes the proposal to change the circularity for the footwear industry.



**Fig. 2.** Proposal for the footwear industry

The changes are made in the phases: of the raw material, with the insertion of reused materials from the footwear industry and other industries; in the production phase, where production waste should be reprocessed for reuse; and, finally, the phase of recycling and reuse of footwear, where it would be possible in recycling to create collections of whole footwear, in parts or only some of the materials [28], for reuse in the extraction of organic materials for fertilization and incineration for energy recovery [29], or the creation of new products or materials. For this last phase it would be necessary to create collection points and a company that carried out an analysis of the state of the footwear, with the maximum objective of the footwear not being deposited in landfills.

## Conclusions

In order to improve the footwear industry, there is a proposal to improve the circular economy in the footwear industry, the improvement encourages the insertion of the use of reused materials in new productions, such as the creation of collection points that are associated with the analysis of footwear to reuse.

The company's objective would be to make the most of the materials from the dismantling for the same production category or for the reuse of the materials for new production, which in addition to being an investment focused on the environment would eventually be another system for job creation. For the creation of this investment the Analysis SWOT [30] (strength, weaknesses, opportunities, threats) presents that for project planning:

As strength the company will be innovative, will collect various types of footwear, reuse the materials used for new production or for sale to companies in the same sector, the footwear will be reused to the maximum, and ultimately generate new jobs.

As weaknesses the company will have production peaks, because it will have dependence according to the discards of society, the times of the production processes will also be dependent on the state of the footwear, which in turn may have to go through a variety of disassembly processes. With production dependencies it will be difficult to match large orders of products.

As opportunities the creation of the company would contribute to the reduction of footwear in landfills; new products and materials can be developed and with the membership of the society marketing strategies will be created to further influence the action of shoe recycling.

Finally, the threats related to the planning of setting up a company for the collection of used footwear will primarily be the costs associated with the collection of footwear and the company's production process; and competing companies, from raw material companies, fertilizers and companies that collect their products after use, among others.

The implementation of this project would correspond to the circularity action in the footwear industry, the valorization and resale of second-hand products and the creation of new materials and products from footwear materials and components.

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