EUROPEAN JOURNAL OF MATERIALS SCIENCE AND ENGINEERING
Volume 8, Issue 2, 2023: 108-112 | www.ejmse.ro | ISSN: 2537-4338

EJMSE

DOI: 10.36868/ejmse.2023.08.02.108

THE INFLUENCE OF ZERO WASTE SEWING PATTERNS UPON THE APPAREL'S CO_2 FOOTPRINT

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Abstract

The article depicts the study that has been conducted in investigating the impact that the sewing patterns have in regard to the carbon footprint of a single garment unit. The research has been conducted by following a practical method of drafting Zero Waste sewing patterns, that can be applied in the conceptual apparel's design, with the aim to prevent the generation of pre-consumer fabric waste throughout the manufacturing process, and thus preventing unnecessary CO_2 emissions. The results provide valuable insight, which prove that by using geometric patterns, the CO_2 footprint for a single garment unit can be reduced by 0.003 kg CO_2.

Keywords: *apparel, CO_2 footprint, efficient fabric consumption, pattern pieces, zero waste.*

Introduction

The textile industry is one of the third most polluting industries on a global level, being responsible for 10% of annual global CO_2 emissions [1]. Furthermore, there is expected the CO2 emissions in the textile industry to increase by more than 50% by 2030 [2]. Given the swift increase of the apparel production peace, along with the concerning predictions concerning the negative impact of the fashion industry on the environment, the United Nations (UN) Climate Change has developed a strategy to support fashion corporations (brands, suppliers, retailers) to shift towards adopting sustainable business models, thus sustaining in reducing the carbon footprint of each enterprise [3,4]. This highlights the great importance that is worldwide attributed to the measures taken to undo the harm that has been done over the years, as well as prevent the increase of the negative impact that the fashion industry already has.

Carbon emissions are generated throughout the entire life span of a clothing item, whether during the production of raw materials, manufacturing, transportation, use, or disposal. Those responsible for managing the CO_2 footprint of garment items are both the producers and the consumers. What once was advisable has now become mandatory, for sustainability to manifest within the industry At the European level, it is expected that by 2030 textile products on the market to correspond to certain sustainable criteria, which implies that consumers will be able to purchase higher quality clothing items, designed in a manner that ensures durability [6]. Other key factors are involved in the process of the product's design, apart from the textile's fabric quality features, such as the structural engineering that goes hand in hand with the design process. Nonetheless, around 80% of the environmental impact of a product, throughout its entire lifecycle, is established during the design process [7].

Considering the carbon footprint that the product has developed, even before its manufacturing, through the emissions generated during the raw materials extraction and

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production, and other logistic factors, it is imperative to find suitable design resolutions to assist in reducing the impact that the garment piece has on the environment, throughout its life cycle. Addressing the carbon emissions that are generated during the manufacturing process, from a pattern maker's perspective, the main element that can be controlled are the sewing patterns, and, more specifically, how their shape and their placement within the marker can ensure the complete utilization of the textile surface.

Zero waste patterns have become an accessible topic lately, which succeeded to establish new perspective concerning pattern making, as well as garment geometry and product fit. With the intent of integrating the entire fabric area within the final product, the aesthetical principles have become less of a priority. Once unusual and different, the garment items that have been obtained by using geometrical sewing patterns have become more common and accepted amongst the consumers and designers alike, as redesign solutions have been developed by designers [7-9]. Furthermore, the notion of integrating these particular type of sewing patterns within mass production has been widely debuted and analyzed [10-12]. This fact alone indicates the increased interest in implementing and normalization of using geometric patterns within the industry.

The differences between the classical and geometric pattern pieces have been emphasized within the current article, by illustrating the experimental research that has been conducted, aiming to identify the real impact each pattern set has upon the product's life cycle.

Methodology

The current research aims to analyze and identify the CO_2 footprint for two distinctive clothing pieces, that have been assembled using two different pattern sets – classical and geometric. For experimental purposes, the study has been entirely conducted in the virtual space. The pattern pieces have been drafted, altered and nested within the Gemini CAD Systems software. The life cycle for both garment units has been simulated using the Mobius LCA Software, using the Ecoinvent inventory database. The virtual prototype for both products has been generated by using the CLO 3D software. The products analyzed are two basic blouses, corresponding to ladies' wear, size S.

The experiment was initiated with the process of redesigning the classical pattern pieces, drafted as a result of a previous study. Also, the body measurements were used as a reference, in order to accurately dimension the new set of patterns. Nonetheless, they were used for the configuration of the virtual mannequin on which the end results were fitted.

During the redesign process, the make technology was an important factor based on which the patterns have been shaped, in terms of seam allowances dimensions, types of stitching and technological options for fabric manipulation. Since geometric patterns are defined by loose fit and straight cut, fabric manipulation techniques were used, in order for the final product to be fitted on the waistline. Thus, it has been decided to create a series of elastic stitching, which would gather the fabric on the destined body area.

In order for the patterns to be considered as being zero waste, the marker has to meet certain criteria, such as width corresponding to the fabric's usable width and over 95% marker efficiency. Testing those parameters was conducted within the Gemini Nest Expert software.

The fabric width is an important factor, as well as the main restriction, in terms of drafting the zero waste patterns. Considering the jigsaw pattern placement, according to which the pattern pieces are placed in close proximity to one another, filling out the gaps between them, much like puzzle pieces. The end result, depicted as the marker, that contains all the pattern pieces efficiently placed, is defined by two major parameters: width and length. Those dimensions are linked with the fabric surface which will be processed during the cutting process. Therefore, for a marker to be considered zero waste, its width has to correspond with the width of the fabric assigned. A wider marker won't fit within the fabric, and a narrower marker will result in an area of unused fabric, thus coming against the zero-waste philosophy. The length of the marker is of a lesser importance during this stage, and acts as a rather informative data, as it indicates the fabric rating (Table 1).

Table 1. Fabric entry data for the LCA, obtained after generating the markers for both pattern sets.

Fabric name	Textured cotton knit	
Usable width [cm]	112	
Fabric density [g/m^2]	260.1	
Fabric rating [m^2]	By using classic patterns 1.15	By using geometric patterns 1.05
Weight/rating [kg]	Classic patterns 0.29	Geometric patterns 0.27

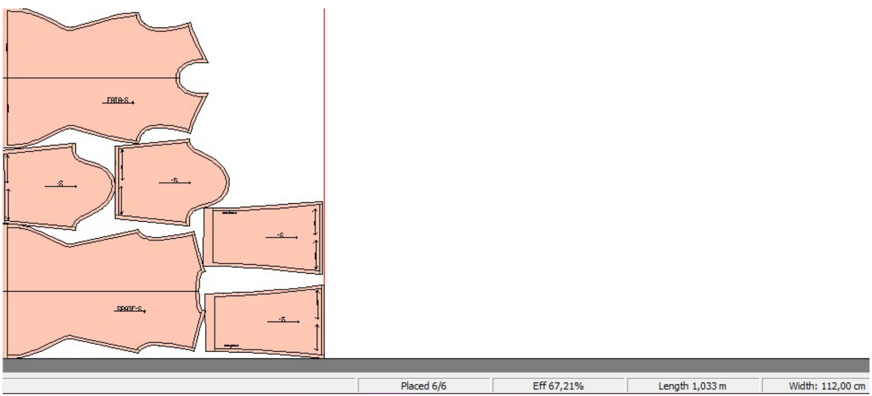
Within the next step, the raw material rating (consisting in fabric and sewing thread) was able to be identified. The information obtained was later be used as entry data for the LCA analysis. Other relevant data, such as supplier and manufacturing factory location, lifetime treatments and end of life processing, has been established through estimation, in order to accomplish the complete scenario of the life cycle for both items.

Results and Discussions

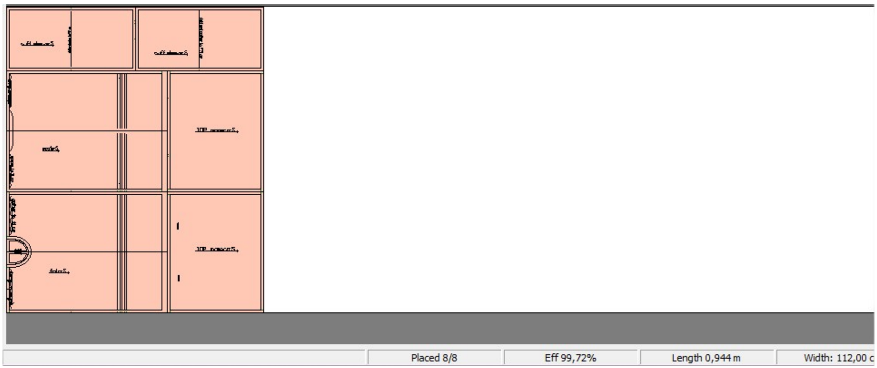
The data collected has been processed within the Mobius workspace. A complete life cycle analysis has been conducted for both garment items. The results obtained prove that geometrical patterns alone have the capacity to reduce the carbon footprint of a garment item by 3.53%, compared to the classical patterns. This detail on its own is reflected by the absence of fabric waste generated during the cutting process, which alone generates 0.03 kg CO_2 eq.

An important factor that has a resounding influence throughout the product's life cycle is the quantity of fabric needed to make a garment unit. By using zero waste patterns, not only that fabric scraps are removed, but a better consumption can also be obtained.

Within this study, the fabric rating has been reduced by 8.7%, and the marker efficiency has been increased by 32.5 %. When using the classical patterns, the marker efficiency was 67.2%, meaning that 32.8% of the layplan consists in fabric that will be wasted during cutting (Fig. 1). The improvement that has been attained, concerning the fabric usage, is reflected by the 99.7% marker efficiency, thus depicting the complete integration of the fabric surface in the final garment product.



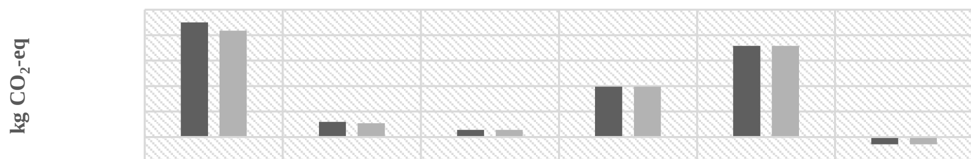
a)



b)

Fig. 1. Layplans generated using: a) the classical pattern set; b) the geometric redesigned patterns set.

It is of great importance to mention that the end-of-life process is another element that can be used as a tool in diminishing the CO_2 footprint. Based on the given scenarios, the garment item can either be incinerated (0.1 kg CO_2 -eq), landfill discarded (6.13 x 10 -2 kg CO_2- eq), or recycled (-0.14 kg CO_2-eq). For this particular study, the latter scenario has been assigned. The results are summarized in Fig. 2.



	Raw materials	Production	Packaging	Transport and distribution	Use (3 years)	End-of-life
Clasic	2.25	0.3	0.14	0.99	1.79	-0.14
Zero Waste	2.09	0.27	0.14	0.99	1.79	-0.14

Fig. 2. The comparison of the carbon footprint for both garment items, measured throughout the product's life cycle.

The fitted garments are depicted below. The aim of the redesign process was to maintain the product's functionality: a long sleeve blouse, size S.

a) b)

Fig. 3. Virtual prototypes for: a) the classical; b) the zero waste (right) products

Conclusions

Altering the shape of a given pattern set is a complex procedure, which ensures not only the development of a zero waste lay plan, but also enforces the engineering of new garment pieces, from an aesthetic and technological perspective.

During pattern drafting, it is mandatory for the pattern maker to always keep in mind the technological aspects regarding the making process of the garment item. By designing a product, with the intent for it to easily disassemble at the end of its life, the pattern maker needs to consider using plain stitches, thus facilitating the recycling process.

The utilization of geometrical patterns does not provide a carbon free garment item, however it does make a difference in the product's overall footprint. This is attainable, both through the minimization of the fabric waste, as well as the reduction of the fabric rating. A smaller quantity of fabric used to make a clothing item will echo throughout the future life stages, and impact the carbon footprint during transport, use or disposal.

This analysis alone highlighted the importance of a proper management of the pre-consumer fabric waste, along with the impact this element has throughout the fabric's life cycle, in terms of the CO_2 emissions. Last but not least, in order for change to manifest withing the apparel industry, sustained effort is needed, and preventing global warming from further development is a concern that must be shared by producers and consumers as well.

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Received: April 24, 2023
Accepted: May 28, 2023