3D PROTOTYPING AND ARTISANAL WOOL RECYCLING TECHNIQUES IN MENSWEAR DESIGN

FLOREA-BURDUJA Elena, IROVAN Marcela,
RARU Aliona, BUJOREAN Tatiana
Technical University of Moldova, Faculty of Design, Chisinau, Republic of Moldova
elena.florea@dtt.utm.md

This paper analyses the efficiency of integrating digital 3D prototyping solutions, particularly CLO 3D software, with manual wool waste processing methods for the development of a sustainable menswear collection. The research demonstrates how the digitalization of the design process enables precise product visualization, optimizes base construction, and significantly reduces material waste by eliminating intermediate physical prototypes. At the same time, the reuse of textile waste through techniques such as carding and dry felting adds superior aesthetic and ecological value to the final product, transforming waste into creative resources. The results highlight that this hybrid approach represents a viable solution for the fashion industry.

Key words: *wool recycling, 3D prototyping, sustainable fashion design, recycled materials, virtual prototype.*

INTRODUCTION

In the current context of the climate crisis, the textile industry faces an urgent need to adopt sustainable production models. Wool, recognized for its thermoregulating properties, breathability, and durability, represents an ideal material for recycling. However, processing wool waste requires innovative approaches to overcome economic and technological barriers [1].

The implementation of 3D technologies in fashion design is no longer merely an aesthetic option, but an ecological necessity. CLO 3D software enables the simulation of fabric behaviour on digital avatars, allowing designers to correct fitting defects before cutting the material. This paper proposes a fusion between the rigor of digital algorithms and the artistic unpredictability of manual wool recycling techniques, demonstrating that technology and craftsmanship can coexist to generate high-quality products [2].

PURPOSE

The aim of this research is to demonstrate the viability of sustainable design through the fusion of digital prototyping with manual wool recycling techniques. The study focuses on transforming textile waste into value-added menswear products, optimizing the production process and reducing environmental impact by eliminating physical prototypes and capitalizing on secondary resources. The proposed approach strengthens the circular economy and demonstrates the efficiency of integrating digital technologies into contemporary artisanal processes.

RESULTS AND DISCUSSION

A. Manual Processing of Waste

At the initial stage, the research focused on artisanal techniques for valorising wool waste. An innovative element presented in the thesis is the use of a custom-made miniature carding cylinder designed to restore wool fibres to a primary state, ready for reuse (Figure 1).

Fig. 1. Wool preparation process and tools used [3]

The presented tools enabled the creation of a wool layer subsequently used in the dry felting technique, applied to produce unique textures and decorative inserts directly on garments. By using special needles of different sizes, the recycled fibers were mechanically interlocked into the base fabric structure, resulting in a three-dimensional effect and an organic aesthetic (Figure 2). Finally, mechanical decorative stitches were applied.

Fig. 2. Creation of decorative elements [3]

B. 3D Prototyping as a Bridge to Sustainability

In parallel with the manual processing of waste, the garment construction was developed [4]. The use of CLO3D software in this thesis represented the technical core of the creative process [5]. The design process included selecting a digital avatar, modelling shapes, and applying textures simulating recycled wool (Figure 3).

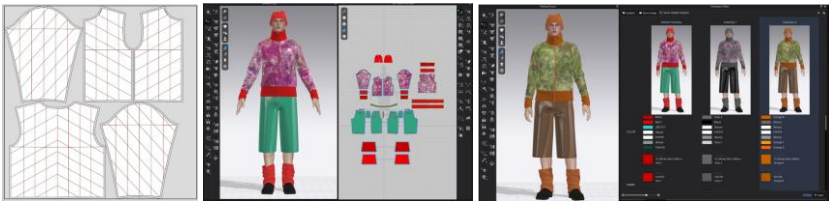

Fig. 3. 3D prototyping and model diversification in CLO3D [3]

During the workflow using the Colorway tool, various colour palettes and previously created manual textures were tested. This enabled rapid creation and visualization of multiple variations of the same design without reconstructing patterns from scratch. The process facilitates the quick identification of optimal solutions for the collection and allows precise evaluation of which colours and materials will be most attractive to the final consumer (Figure 3).

The use of 3D prototyping software in garment creation has revolutionized the way sustainable concepts are translated into reality by offering fundamental advantages through digital integration. A major benefit is the drastic reduction of technological waste; through ultra-realistic virtual visualization, the need for multiple intermediate physical samples was eliminated, saving significant amounts of raw materials and energy.

Beyond the ecological aspect, construction accuracy is optimized through advanced simulations that allow real-time verification of fabric tension and precise body fit, ensuring superior quality and impeccable ergonomics of the final product. Moreover, the flexibility of the digital process supports rapid collection diversification, enabling extensive creative exploration within a fully controlled and sustainable environment.

CONCLUSIONS

This research confirms that the integration of advanced digital technologies with traditional waste-processing techniques is not merely an experimental approach, but a strategic direction for the evolution of sustainable fashion design. The incorporation of CLO 3D prototyping software into the development of the menswear collection fundamentally restructured the creative and technical workflow. By enabling precise geometric construction, accurate fit simulation, and real-time material behavior analysis, the digital environment replaced the uncertainties associated with conventional flat-pattern methods. Virtual simulations allowed continuous refinement of proportions, balance, and ergonomics before any physical intervention, significantly reducing material consumption and eliminating the necessity for multiple trial prototypes. As a result, both technological waste and energy use were substantially minimized at the design stage.

At the same time, the manual recycling of wool, through miniature cylinder carding and dry felting, introduced a complementary dimension rooted in craftsmanship. These techniques restored discarded fibers to functional and expressive value, transforming waste into textured surfaces and structural decorative elements. The tactile irregularities and subtle inconsistencies of manually processed wool generated a distinctive aesthetic language. When inserted into garments constructed with digital precision, these organic qualities created a deliberate contrast between algorithmic order and material spontaneity. This dialogue defines a contemporary interpretation of sustainable luxury, where authenticity and innovation coexist.

The strength of this hybrid model lies in its systemic coherence within the circular economy framework. Digital prototyping optimizes efficiency and lowers the carbon footprint during conceptualization, while artisanal recycling directly addresses textile waste at the material level. Together, they form a closed-loop logic that connects design intelligence with responsible resource management. The

findings clearly demonstrate that digitalization does not replace craftsmanship; rather, it amplifies its expressive and functional potential.

The study proves that wool waste, frequently underestimated, can become a source of high value-added menswear products. By combining technological rigor with manual sensitivity, designers gain the capacity to produce garments that are innovative, ethical, and economically viable. The future of the textile industry depends on this equilibrium between digital precision and human touch.

REFERENCES

1. Bingnan Mu, Xiaoqing Yu, Yiqi Yang. *Sustainable and green process for recycling waste wool textiles into high-quality protein fibers on a pilot scale*. Resources, Conservation and Recycling, Volume 198, 2023, ISSN 0921-3449. https://doi.org/10.1016/j.resconrec.2023.107190.

2. Sema Bahar Erdem, Nurdan Buyukkamaci, Safak Birol. *Environmental benefits of virtual sampling for garment production.* Journal of Cleaner Production, Volume 538, 2026, ISSN 0959-6526. https://doi.org/10.1016/j.jclepro.2025.147401.

3. Babanschii Tatiana. *Elaborarea colecției de produse pentru bărbați pe baza conceptului de reciclare.* Teză de master. Universitatea Tehnică a Moldovei, Chișinău, 2025.

4. Elena Florea-Burduja, Aliona Raru, Marcela Irovan, Daniela Farîmă. *Tehnici de personalizare a avatarilor virtuali pentru proiectarea digitală a îmbrăcămintei funcționale*. XVII-a ediție a Simpozionului Științific PROGRESUL TEHNOLOGIC – REZULTAT AL CERCETĂRII, organizat de Asociația Generală a Inginerilor din România. https://www.agir.ro/buletine/3290.pdf

5. Saitul oficial al softului CLO3D. https://www.clo3d.com/en/

ФЛОРЯ-БУРДУЖА Є., ІРОВАН М., РАРУ А., БУЖОРЯН Т.

3D-ПРОТОТИПУВАННЯ ТА ТРАДИЦІЙНІ ТЕХНОЛОГІЇ ПЕРЕРОБКИ ВОВНИ В ДИЗАЙНІ ЧОЛОВІЧОГО ОДЯГУ

У цій статті аналізується ефективність інтеграції цифрових 3D-рішень для прототипування, зокрема програмного забезпечення CLO 3D, з методами ручної обробки вовняних відходів для розробки колекції сталого чоловічого одягу. Дослідження демонструє, як цифровізація процесу проектування дозволяє точно візуалізувати продукт, оптимізує конструкцію основи та значно зменшує матеріальні відходи, усуваючи проміжні фізичні прототипи. Водночас, повторне використання текстильних відходів за допомогою таких методів, як кардочесання та сухе валяння, додає кінцевому продукту чудову естетичну та екологічну цінність, перетворюючи відходи на творчі ресурси. Результати підкреслюють, що цей гібридний підхід є життєздатним рішенням для індустрії моди.

Ключові слова: *переробка вовни, 3D-прототипування, сталий дизайн одягу, перероблені матеріали, віртуальний прототип.*