



Hybrid Comfort: 3D Printing Interwoven

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Under the concept of Maker Movement (Dougherty, 2012), apparel researchers and designers are exploring the potentials of three-dimensional printing (3DP) and seeking ways to take the advantages of 3DP and apply it to wearable products. For examples, due to complex shape manipulation of 3DP, fashion trio threeASFOUR (Jacobson, 2017) designed a dress composed with 3DP white bubble shapes, making the model look as if she had just had a bath. However, early applications of 3DP on wearable products (Howarth, 2013) mainly focused on aesthetic purpose, the 3DP parts or textiles were not as comfortable as traditional fabrics (e.g., woven and knitted fabrics). Later, functional 3DP integrations have gradually been explored. Apparel designers are now experimenting new properties for 3DP textiles to make them softer, more comfortable to the wearer. For instance, a UCLA-led research team designed a 3DP lattice by manipulating the internal structure of the material using the selective laser sintering (SLS) printing method. The material developed was soft and porous and is designed to replace the foam cushion inside football helmets (Kisliuk, 2014). However, 3DP has been explored heavily in the fashion accessory product category or in art form and limited in ready to wear garment designs with practical applications. To enable comfort and function, 3DP wearable products should provide demonstrate their advantages in textile properties and even their high potential to disrupt the traditional apparel industry are crucial in this design case study.

This design case study aimed to integrate 3DP textiles in a beach vest to allow new properties and functions to emerge with aesthetics. Explicitly, this study applied the research through design (RTD) methodology (Jonas, 2007) to explore the properties of 3D textiles by manipulating the structure of thermoplastic polyurethane (TPU) materials using the Fused Deposition Modeling (FDM) 3DP method.

A “hybrid” 3DP textile was explored and developed in this case study. “Hybrid” refers to the integrations of two different structures (woven and knitted structures). Further, the hybrid 3DP textiles were integrated with traditional fabrics for a men’s beach vest design. A beach vest needs to be durable, flexible, water-resistant, keep warm and comfortable in inclement weather (Zientek, 2018). In this case study, a men’s vest was developed for beach wear using water-resistant neoprene knit and 3D printed TPU. While the hybrid 3DP textile is water-resistant, flexible, but also porous and could provide venting. Six hybrid 3DP textiles pieces were sewn with neoprene fabrics on the front midriff part, with three inserted on each side, and two were on the back shoulder yoke to form the functions of beach vest. The beach vest also has a silver waterproof zipper on the center front and a stand up collar. The mimicry of woven and knitted fabrics is also the aesthetic feature of the hybrid 3DP textile and embellished in neoprene fabrics to be aesthetically appealing.

An objective of this study was to develop a 3DP textile structure that mimics and combines both woven and knitted structures in order to manipulate the flexibility in the structure. Various small structures were explored virtually in 3D CAD modeling program – Rhinoceros (Rhino). The CAD design workflow has three steps: (1) mimic the structures of traditional woven and knitted fabrics; (2) connect and integrate two structures to form repeatable patterns, and (3) check patterns to avoid collision. Through several iterations using such design flow, a hybrid 3DP textile was developed. Various structure dimension and thickness were sampled using TPU in FDM printer. Considering the final vest venting needs, the 3DP structure was modeled with 1.4 mm thickness for each interwoven line and printed in 2 x 4 inches and an overall 4 mm thickness. The hybrid 3DP textile was tested in resilience before finalization. Pattern making techniques were applied to develop the final garment design.

Key findings in this design case study were mainly focused on the explorations of new properties for 3DP textiles. 3D CAD modeling program provided virtual manipulations of the 3DP textile structures and offered visual evaluations of the 3DP textile properties. The final 3DP textile structure evaluations suggested some expected properties (e.g., flexible, strong), while revealed new properties (e.g., porous, cushioning). Further, the specialty 3D printed TPU material was unique in its resilient and flexible properties. The use of FDM printing method also confirmed its capability to print relatively complex structures inexpensively. However, the FDM 3DP process is limiting in the minimal object thickness and requiring structure support parts. 3DP textile cannot be prototyped with the ideal property and may require post-finishing time to clean the support parts.

Overall, the research findings suggest that the explorations of 3DP textiles could enable some properties of traditional fabrics but also generate new properties. This case study provided a research orientation and called for future 3DP textile research on traditional fabric to enrich the 3DP textile functional properties based on structure manipulation. The integration of 3DP textile and traditional fabrics should be further explored to meet functional and aesthetic needs in existing and new product categories. Also, the hybrid 3DP textiles may be applied to other wearable products to have a holistic comprehension of such hybrid 3DP textile structure. From 3D CAD modeling perspective, design logic, workflow, and cognition may be explored to ensure design efficiency.

Reference

- Dougherty, D. (2012). The Maker Movement. *Innovations*, 7(3), 11-14.
- Howarth, D. (2013, March 7). 3D-printed dress for Dita Von Teese by Michael Schmidt and Francis Bitonti. *Dezeen*. Retrieved from <https://www.dezeen.com/2013/03/07/3d-printed-dress-dita-von-teese-michael-schmidt-francis-bitonti/>
- Jacobson, R. (2017, May 12). The shattering truth of 3D-printed clothing. *Wired*. Retrieved from <https://www.wired.com/2017/05/the-shattering-truth-of-3d-printed-clothing/>

- Jonas, W. (2007). Design research and its meaning to the methodological development of the discipline. In R. Michel (Ed.), *Design research now* (pp. 67-80). Basel, Switzerland: Birkhauser Verlag AG.
- Kisliuk, B. (2014, November 13). UCLA-led team wins grant to tackle concussions among football players. *UCLA Newroom*. Retrieved from: <http://newsroom.ucla.edu/releases/ucla-led-team-wins-grant-to-tackle-concussions-among-football-players>
- Zientek, J. (2018, January 30). The story behind a forgotten American outerwear brand with a cult following. *Gear patrol*. Retrieved from <https://gearpatrol.com/2018/01/30/browns-beach-jacket-company/>

