3D PRINTING ON PRESTRESSED CUSTOM KNITTED TEXTILES

ABSTRACT

This paper investigates the technique of 3D printing on prestressed fabrics as a way of creating three-dimensional textile composites and explores potential applications of this method in the architectural industry. Design methodology take advantage of the elasticity and self-shaping properties of these structures, looking into aspects such as materiality, modularity and scalability.

Design methodology relies on 3D printing a less elastic material such as thermoplastic polymer on top of an elastic, pre-stressed fabric. After releasing the tension, the fabric transforms into a three-dimensional textile structure. This self-forming process results from the interplay and search for the balanced state between the two opposing elements: the elastic, prestressed fabric and the stiffer, 3D printed polymer. Forms created in this way are pure representations of their material properties, energy stored in these materials and forces acting on them. As a result, they are structurally stable and inherently efficient.

The study consists of two parts. The first one aims to understand the physical and geometrical principles that influence the shape transformation. In nature, out-of-plane deformations of flat sheet materials are often the most energy-efficient solutions to deal with material access. Examples of such systems are kale leaves or seashells, which curl towards the perimeter since it costs them less energy than extending. In the case of prestressed fabrics, their embodied energy acts in the opposite direction and causes shrinkage, whereas the excess 3D printed material deforms out of plane creating wrinkles and curls.

The second part of the research focuses on the fabric itself by looking into the relationship between the knitted pattern and the self-shaping properties of the textile composites. It investigates 3D printing on custom-knitted fabrics with various degrees of porosity and elasticity. Being able to control the trajectories of individual fibers results in efficient material distribution and allows integration of various functionalities into one heterogenous knitted fabric. The purpose of this study is to explore how the pre-programmed knitted patterns affect their three-dimensional transformation.
Both parts of this research are examined through a series of physical experiments and analytical studies.

As additive manufacturing becomes more affordable, materials more intelligent, and textiles more robust, the pool of potential applications of textile systems is continuously expanding. Proposed methodology suggests novel applications for lightweight textile structures in architecture and construction.

KEYWORDS

self-shaping textiles, material form-finding, 3D printing on textiles, custom knitted fabrics