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Enhancing 3D-Printed Bra Cup Design Through Lattice Structure Optimisation ⋆

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Abstract

With the development of 3D printing technology, its application in the apparel industry, especially in bra cup design, has drawn attention. Previous studies have explored the use of 3D printing for underwear customisation. Yet, issues such as poor flexibility, heavy weight, excessive material consumption, and low comfort of printed materials remain, limiting the wide application of 3D-printed bra cups. There is a research gap in effectively optimising the structural design of 3D-printed bra cups to overcome these drawbacks. This paper aims to address this gap by investigating the use of lattice structures in designing 3D-printed bra cups and analysing how rod diameter and material hardness affect the elastic modulus of the lattice-based cup designs. Through a series of experiments, it is found that both parameters significantly influence the modulus, with material hardness being more crucial. By using the RESIONE F80 material with a 1 mm rod diameter for lattice infill, the volume of the 3D printed cup is reduced by 45.16%, porosity is enhanced, and ventilation and comfort are greatly improved.

Keywords: 3D Printing; Lattice Structure; Bra Cup; Comfort

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1 Introduction

Additive manufacturing, also known as 3D printing, is a technology that builds things by layering materials [1]. As 3D printing technology advances, it has been widely used in many industries, particularly apparel. Unprecedented disruptive innovations have been brought about by this technology [2, 3], particularly new possibilities for the design and production of moulded cup bras. Its benefits are mostly shown in the following: (1) This technique may create customised goods based on client requirements by doing away with the conventional mould production process. (2) Material waste is significantly decreased by progressively adding layers of materials to achieve near-net formation. (3) It can also produce goods with intricate structures, increasing design flexibility.

The use of 3D printing for the individualised customisation of underwear has been studied. The benefits of this technique above conventional approaches were disclosed by Wang et al., who also identified its drawbacks and recommended technical advancement to encourage its use [4]. To get a comfortable fit, Kajtaz et al. concentrated on customising sports bra cups using 3D printing and reverse engineering [5]. A thorough review of the use of 3D printing in the garment industry was given by Vanderploeg et al., who included examples from the fashion, underwear, and smart clothing industries. They spoke about its potential for development and provided a useful resource for relevant studies [6]. However, issues still prevent the current state-of-the-art 3D-printed bra cups from being widely used. Compared to typical bra goods, there is a noticeable difference in comfort and wearability because of problems including excessive weight from printing materials, poor breathability, and higher manufacturing costs because of the printing method and material properties. These restrictions prevent 3D printing technology from reaching its full potential in intimate clothing. This study suggests using lattice structures strategically to optimise the structural design of 3D-printed bra cups to solve these urgent issues. Through thorough investigation, testing, and methodical assessment of several lattice configurations, the study seeks to determine the best structure that may be used to fill the bra cup model. This method will make it possible to compare the structural characteristics of the bra cup model before and after the lattice-based optimisation, offering important information to enhance the 3D-printed bras' comfort, breathability, and affordability.

To fully realise this technology's revolutionary potential in the apparel sector, 3D-printed bra cups must overcome their present constraints. This study's results will improve the practicality of 3D-printed intimate clothing and offer new design approaches that may be used in other 3D-printed fashion and textile product categories.

2 Method: Lattice Structure Compression Elasticity Experiment

2.1 Lattice Structure Selection

There are two-dimensional categories of lattice structures: two-dimensional and three-dimensional. Strong compressive and bending resistance, high impact resistance, and the capacity to absorb energy are all attributes of two-dimensional lattice systems. Three-dimensional lattices can have superior mechanical properties in various directions and offer great design flexibility [7]. From a prac-