

Varying fabric drape by 3D-imprinted patterns for garment design

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Abstract. Drape is one of the most important properties of fabric, which significantly influences the appearance of a garment or technical textile. Being closely related to stiffness and other mechanical parameters, drape is also influenced by seams and other modifications of the pure textile fabric. In most investigations, the drape coefficient according to Cusick is used to measure drape, using a special drape meter, which allows to quantitatively describing the textile’s behaviour in terms of drape coefficient, number of nodes, etc. This article gives an overview of possibilities to modify fabric drape by printing different geometrical patterns on textile fabric. Their geometry and distance also influence on fabric drape. The resulting differences in a real garment using a skirt as an example will show the impact of 3D printing on garment drape.

1. Introduction

Drape is one of the most important properties of textile fabric which allows a fabric to be bent in more than one direction by creating different folds pleasant for the eyes. This property is of great importance for garment design and production for the selection of the appropriate fabric for a specific product. This characteristic is most often measured using a drape tester according to Cusick, as described, e.g., in EN ISO 9073-9. According to this standard, a circular textile fabric is placed between two smaller circular disks, with its projecting area hanging due to gravity. Using a parallel light beam from below, the shadow of the hanging fabric is projected onto a circular paper ring on top of the textile. The drape coefficient is defined as the percentage of shadowed area in relation to the complete circular paper ring. For the first tests, textile fabrics and circular ring should have a diameter of 30 cm, resulting in the drape coefficient d_{30} . Further tests with smaller or larger diameters for very soft or stiff fabrics, respectively, are also described in the standard.

In different studies several parameters have been proposed to quantitatively assessing fabric drape. The effect of seams is evident in several studies made by different authors. Increase in stitch density increases the drape coefficient on viscose fabrics [1]. Earlier investigations of other research groups concentrated, e.g., on the drape of geotextiles [2] or fabrics for composites [3] and investigated the influence of seams [4] and metallized yarns [5]. However, only few reports about coatings or 3D prints on textiles can be found yet [6,7], although especially 3D printing allows punctually changing the mechanical properties of a textile fabric [8,9], and the adhesion between textile fabric and 3D printing polymer has been investigated and optimized in several former projects [10,11].



The paper thus depicts examinations of the fabric drape, depending on 3D printed different patterns on textile fabric. The influence of such 3D printed patterns on the drape of a complete fabric is shown using a skirt as an example.

2. Methods and Materials

Geometrical patterns, such as squares, triangles and circles in different orientations, were 3D printed on textile fabrics. The printed patterns are depicted in Fig. 1. Some patterns were printed only along the outer part of the tested fabrics, similar to the area in which it is ideal to print on a skirt without impeding the wearing comfort, while other patterns were printed on the entire fabrics. Some of the latter were excluded from further evaluation due to the composite fabric becoming too stiff.

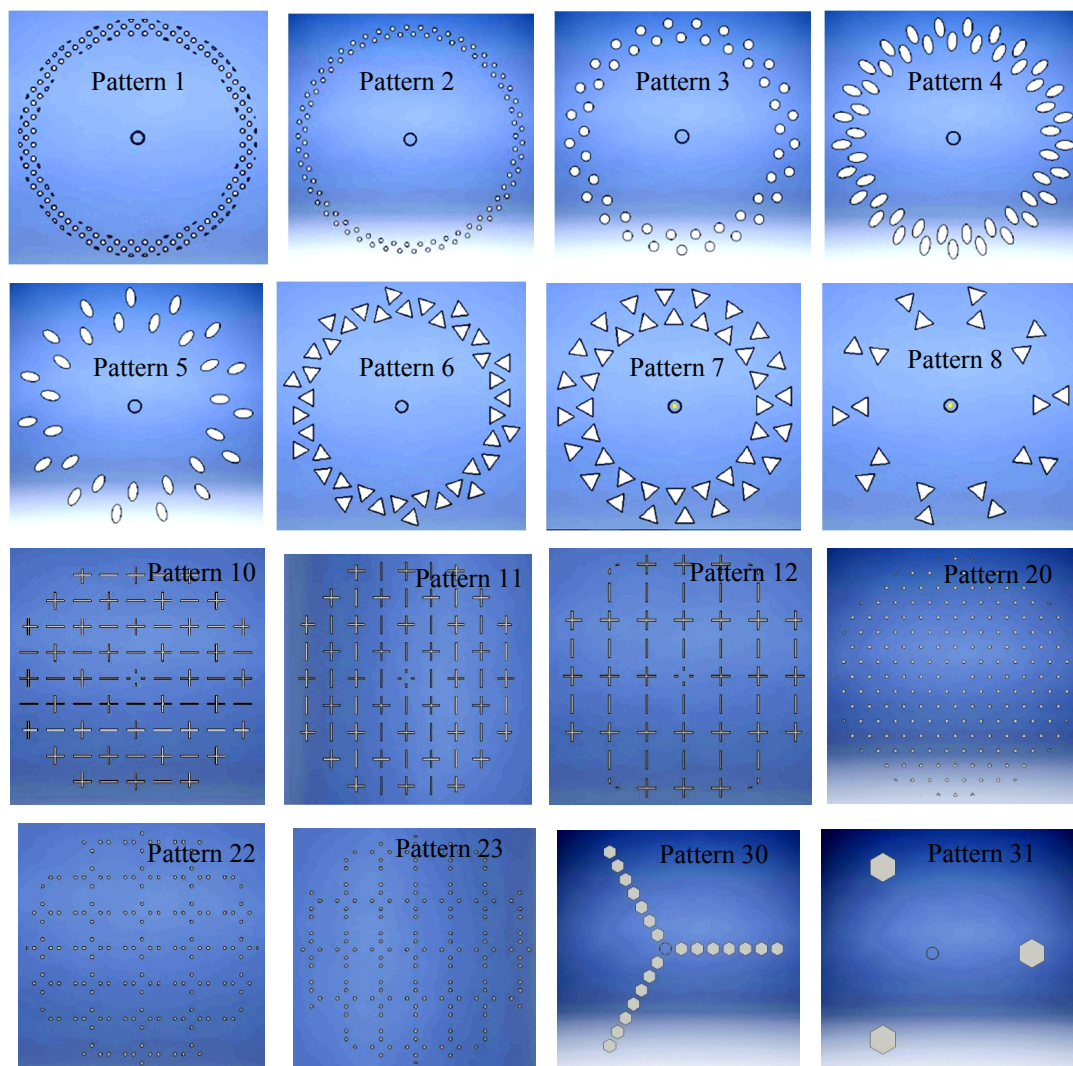


Figure 1. Different patterns for 3D printing on textile fabrics.

The properties of textile fabric used for 3D printing are: white polyester, thickness 0.67 mm, areal weight 136 g/m²; and grey polyamide, thickness 0.46 mm, areal weight 172 g/m². For printing, the FDM (Fused Deposition Modelling) printer Orcabot XXL (Prodim International) was used. As filament material, PLA was chosen which has proven to show superior adhesion to most textile fabrics. Printing was performed at a nozzle temperature of 215 °C and a heating plate temperature of 90 °C, using a 0.4 mm nozzle.

A self-built drape tester according to Cusick was used to investigate fabric drape. Drape coefficients were calculated by semi-automatized image analysis according to EN ISO 9073-9.



Figure 2 Drape test of pure textile fabric (left) and a fabric with a 3D-imprinted pattern (right panel).

3. Results and Discussion

Drape profiles of different 3D printed geometries on the white fabric shows differences of textile fabric. Fig. 3 depicts exemplarily typical situations in the drape tester, depending on the imprinted 3D pattern. The printed patterns modify the soft, irregular drape of the pure textile fabric.

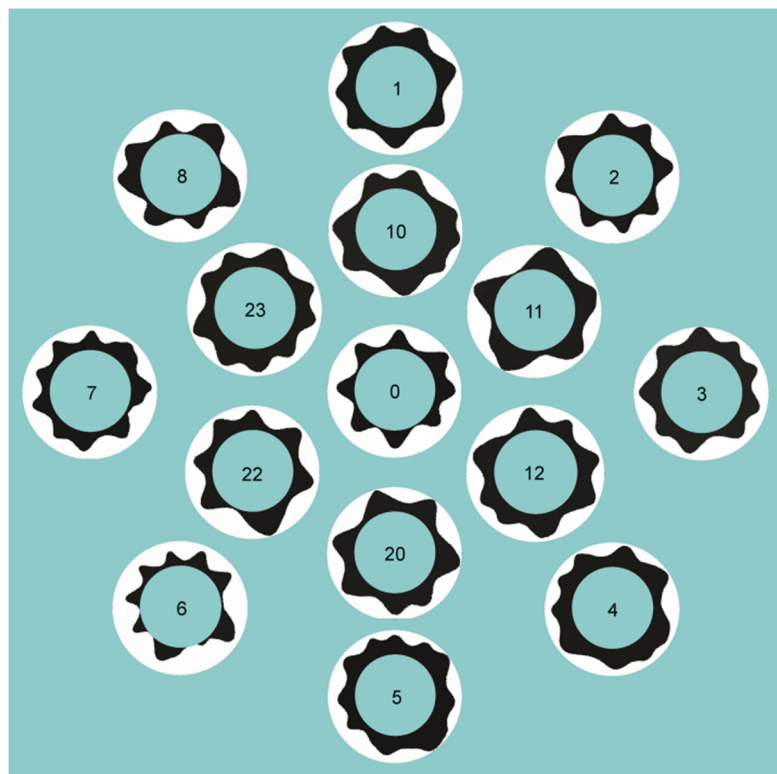


Figure 3. Drape profiles of pure textile fabric (image no. 0) and textile fabric with 3D-imprinted geometries.

As visible in Fig. 3, fabric drape is strongly modified by 3D printed geometries in terms of drape coefficient, number of nodes, and regularity. This is affected not only by the shape of the 3D printed geometries but is also linked with their weight and the free spaces between the imprinted areas. In Fig. 4, the results of the drape coefficients (DC %) tests are shown. As already recognized from Fig. 3, the drape coefficients can be increased as well as decreased significantly by printing a suitable 3D pattern on the original textile fabric.

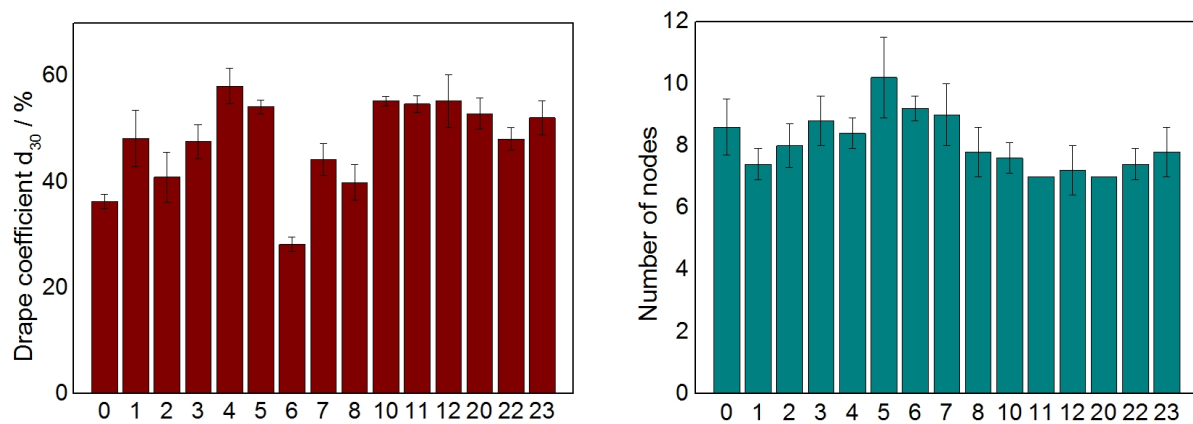


Figure 4. Drape coefficients of the patterns (left panel) and respective numbers of nodes (right panel).

The number of nodes is less strongly influenced by the imprinted 3D patterns. Nevertheless it should be mentioned that the error bars, indicating the reliability of the textile fabric approaching the average number of nodes, are influenced by the 3D printed patterns.

For all patterns, drape was found to be influenced significantly by the 3D printed patterns, especially by the free spaces between the imprinted areas as well as the overall areal weight of the fabric. Depending on the arrangement of the patterns, different effects could be induced, especially with respect to the number of nodes (number of maxima and minima along the separation line between shadowed and illuminated area) and the amplitude (radial distances between maxima and minima, not depicted here).

For the skirt, the desired properties were as follows: drape coefficient ~ 40 – 45 %, small standard deviation to create reliable results, a non-stretchable fabric, and a pattern which does not only create the desired drape coefficient but also a special design. For this, patterns 30 and 31 were tested on both fabrics, resulting in the values given in Table 1. Due to the above described requirements, the grey fabric was chosen for the skirt and printed with an up-scaled version of pattern 30 (cf. Fig. 6).

Table 1. Drape coefficients for different combinations of textiles and 3D printed patterns and respective standard deviations. Advantageous / disadvantageous values are marked green / pink.

	White fabric		Grey fabric	
	Drape coeff.	Std. / %	Drape coeff.	Std. / %
Pure fabric	36.3	1.4	44.9	3.7
Pure fabric + pattern 30	43	3.5	39.8	1.3
Pure fabric + pattern 31	35.5	2.4	40.7	0.9

A flared skirt model was used for testing drape on 3D imprinted patterns. The skirt model was designed and simulated on CLO 3D software [12], and Figure 5 depicts some of the main steps during skirt designing and simulation on a 3D avatar. The generated stress map displaying the friction strength applied to the skirt through colour codes and numerical values (kPa) shows the right fit of the skirt by inputting some of the fabric properties tested before, such as composition, weight and thickness.

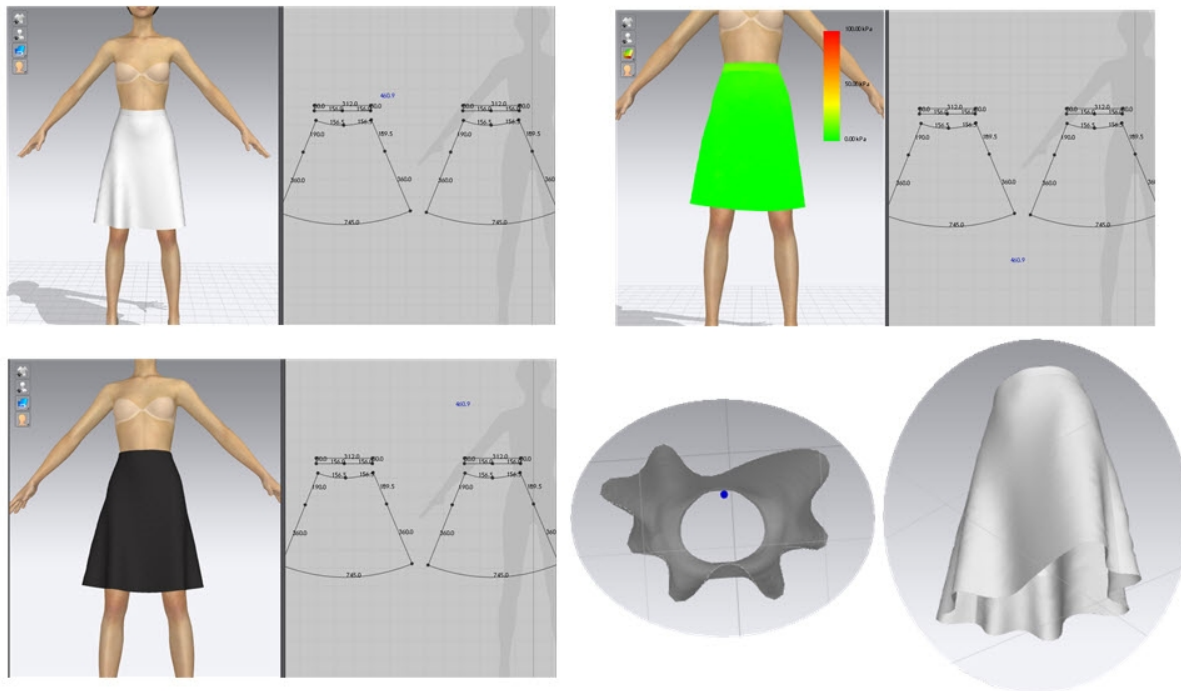


Figure 5. Main steps for virtual skirt designing and simulation.

Afterwards, the skirt patterns were exported, printed and used for fabric cutting and further steps of skirt production. Figure 6 depicts the resulting skirt produced with 3D imprinted hexagon geometries. The drape profiles show regular folds but differ in fold dimensions and numbers.



Figure 6. The skirt with imprinted 3D patterns on front and back.

4. Conclusion

Drape is a crucial factor for the appearance of garments and technical textiles. It is influenced in various ways by 3D printing different geometrical patterns on textile fabrics. In this paper we have tested the influence of different 3D printed geometries on fabric drape. For all patterns, drape was found to be influenced significantly by the 3D printed patterns, especially by the free spaces between

the imprinted areas as well as the overall areal weight of the fabric. Depending on the arrangement of the patterns, different effects could be induced, especially with respect to the number of nodes (number of maxima and minima along the separation line between shadowed and illuminated area) and the drape coefficient. Drape coefficients, numbers of nodes and amplitudes, as defined by EN ISO 9073-9, are reflected in the appearance of the skirt finally created from imprinted textile fabrics.

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