# COMPARISON OF THE REAL AND VIRTUAL FALLING BEHAVIOUR OF TEXTILE FABRICS

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***ABSTRACT:*** *The mechanical deformation behaviour of textiles can be divided into textile drape and drapability. Both determine the overall appearance, aesthetics and fit of garments. In garment simulation, this behaviour must be simulated as realistically as possible in order to enable a meaningful evaluation of design and construction. It is important to understand the relationships between physical textile properties and textile fall. In this study, the real and simulated textile drop are examined and compared. The drop coefficient serves as a numerical measure. The real textile drape according to Cusick and the simulated textile drape are determined for three cotton fabrics with different weave constructions. A subjective image comparison evaluates the simulation quality. As a result of this study, a considerable deviation between simulated and real fabric behaviour can be observed, especially with regard to the anisotropy of textile material. Therefore, further research should focus on the development of simulation algorithms that take into account the anisotropic nature of textiles and ensure that the simulations accurately reflect the behaviour of the fabric in different directions. In addition to the need to ensure access to the simulation algorithms, the introduction of standardized data collection methods is essential for the further spread of simulation in the apparel industry. A coordinated effort to define these standards and best practices will facilitate collaboration and enable more accurate and reliable simulations across different organizations and platforms.*

***Keywords:*** *3D simulation fabric drape, garment drape simulation.*

# POREĐENJE STVARNOG I VIRTUELNOG PONAŠANJA TEKSTILNIH TKANINA PRI OPUŠTANJU

***APSTRAKT:*** *Mehaničko deformaciono ponašanje tekstila može se podeliti na opuštanje tekstila i sposobnost opuštanja. Oba faktora određuju ukupni izgled, estetiku i pristajanje odeće. U simulaciji odeće, ovo ponašanje mora biti simulirano što realističnije kako bi se omogućila značajna procena dizajna i konstrukcije. Važno je razumeti veze između fizičkih svojstava tekstila i opuštanja tekstila. U ovoj studiji, stvarno i simulirano opuštanje tekstila se ispituje i upoređuje. Koeficijent opuštanja služi kao numerička mera. Stvarno opuštanje tekstila prema Cusick-u i simulirano opuštanje tekstila određeni su za tri pamučne tkanine sa različitim konstrukcijama tkanja. Subjektivno poređenje slika procenjuje kvalitet simulacije. Kao rezultat ove studije, može se primetiti značajna devijacija između simuliranog i stvarnog ponašanja tkanine, posebno u pogledu anizotropije tekstilnog materijala. Stoga bi dalja istraživanja trebalo da se fokusiraju na razvoj algoritama za simulaciju koji uzimaju u obzir anizotropnu prirodu tekstila i osiguravaju da simulacije tačno odražavaju ponašanje tkanine u različitim pravcima. Pored potrebe za osiguravanjem pristupa algoritmima za simulaciju, uvođenje standardizovanih metoda prikupljanja podataka je ključno za dalju primenu simulacija u industriji odeće. Koordinisani napor da se definišu ovi standardi i najbolje prakse će olakšati saradnju i omogućiti tačnije i pouzdanije simulacije između različitih organizacija i platformi.*

***Ključne reči:*** *3D simulacija, Opadanje tkanine, Simulacija opadanja odeće.*

## 1. INTRODUCTION

Deformation behaviour is an important factor in material selection, especially in the clothing industry. It influences the appearance, the visual effect and the fit on the body and thus the quality of the garment [1, 2]. The shaping behaviour can be divided into two applications: textile drape and drapability. In addition to the mechanical properties, other parameters are decisive for describing the deformation behaviour of textile surfaces: the drape coefficient, the drape spacing ratio, the pleat depth index, the pleat amplitude and the number of knots [3]. The focus of this paper is on the drape coefficient, as it is used as a numerical indicator for the formation of wrinkles during textile drape [4].
Three different cotton fabrics are compared in terms of their textile-physical deformation behaviour in reality and in the simulation. The results provide information on the reliability of the simulation.
The basis for the test series is the drape test according to Cusick, which is carried out in accordance with DIN EN ISO 9073-9 [5] and provides the textile drape in the form of a drape pattern and the drape coefficient as results.
Clothing simulation is becoming increasingly important in the clothing industry. It has great potential, especially for fit analysis and optimisation in the product development process. The realistic representation of textile fabrics in 3D simulations depending on the material properties remains a fundamental challenge [6]. If the three-dimensional representation accurately reflects reality, it could revolutionise the clothing industry [7].

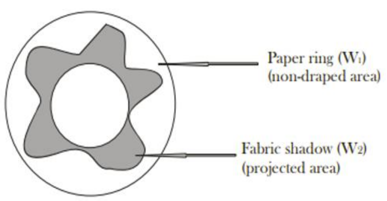
## 2. THEORIE

## 2.1. Textile drape

Textile drape is the ability of a fabric to deform under its own weight and is a key property that influences the aesthetics and functionality of textiles [8]. It is not an isolated property, but depends on various mechanical material parameters such as bending stiffness, elongation and shear stiffness. These in turn are influenced by the type of fibre, construction properties and finishing methods [3, 9]. The textile drape plays an important role in the selection and development of textiles for clothing [10]. Despite the complexity of these relationships, drape can be quantitatively assessed using parameters such as the drape coefficient and the drape distance ratio. These measured variables, which are analysed using digital image processing techniques, can provide the clothing industry with important findings that are helpful for simulation-supported product development and improved communication [3].

## 2.2. Drape test and drape coefficient

The formation of folds in textile material is due to its ability to deform in three dimensions. The drape test was introduced to measure this three-dimensional deformation. This makes it possible to overcome the limitations of two-dimensional stiffness measurement, as used in the cantilever method [11].
The result of the method is a drape image of the material, which can be visually assessed for an initial impression and described by the number of folds, fold shape and alignment of the folds.
The drape coefficient (DC) is used to numerically analyse the drape pattern. It describes the difference between a deformed and a non-deformed surface of the textile material and represents the extent to which a fabric deforms under its own weight [9]. The DC is given as a percentage measure of the ratio of the projected surface of the draped material to the undeformed surface of the material before draping (Figure 1) [12]. Thus, the DC enables an objective description of the drape [9]. In terms of interpretation, a low DC indicates a material that deforms easily, while a higher DC indicates less deformation [13]. However, it should be noted that the DC alone is not sufficient to fully describe the aesthetic appearance of a draped fabric. Fabrics with the same DC can still be characterised by a different drape pattern due to different geometric factors such as the number of knots and the curvature of the draped fabric [4, 14].




$$DC = \frac{\text{Pixels of area under draped sample} - \text{Pixels of area of support disk}}{\text{Pixels of area of specimen} - \text{Pixels of area of support disk}}$$

$$\text{Therefore: } DC\ (\%) = \frac{\text{Pixels of } W2}{\text{Pixels of } W1} \times 100$$

**Figure 8:** Configuration of the covers [Rudolf] Copyright (2020), originally published under a CC-BY licence

The drape coefficient is determined using a Cusick Drape Tester [2]. In this test, the shadow of the draped fabric is projected onto a flat surface and recorded as a digital image. The drape coefficient (DC) is calculated based on the area of the images before and after draping [15].
In order to obtain a more comprehensive understanding of the draping of fabrics, other parameters such as the drape distance ratio (DDR), the amplitude, the wave depth index (FDI) and the number of waves are often taken into account in addition to the DC [16, 17]. The roundness of the drape profile (CIRC) also serves as a measure of the shape of a drape profile [18]. These parameters provide a robust, multidimensional view of the drape behaviour of a fabric [3].

### 2.3. Determining the simulation-relevant material parameters for VStitcher

VStitcher, a 3D software for pattern makers, cutters and technical designers is developed and offered by Browzwear (Browzwear Solutions Pte. Ltd) [19]. Browzwear's digital ecosystem also includes the Fabric Analyser (FAB). The FAB is a proprietary device for recording the physical properties of fabrics, which simultaneously converts the data into a digital format. By using the FAB, the 3D design process is rationalised and the accuracy of the simulation is increased [20]. To analyse the material with the FAB, three test strips are cut: one in the warp direction, one in the weft direction and one diagonally. The physical analysis of the fabric with the FAB includes the mass, thickness, bending stiffness, elongation and shear stiffness, whereby only the mass must be determined separately with a scale [20].

### 2.4. Selection of materials

The selected materials are available in three basic weaves: plain weave, satin weave and twill weave.
Table 1 shows the description of the materials in terms of composition, surface construction and basis weight.

**Table 2**: Tested Materials

| Code | Composition | Weave Type | Yarn Density (wrap/weft) | Weight (g/m²) |
|---|---|---|---|---|
| M05 | 100% Cotton | Atlas Weave | 36/25 | 144,3 |
| M08 | 100% Cotton | Plain Weave | 24/25 | 201,9 |
| M15 | 100% Cotton | Twill Weave | 36/22 | 216,1 |

## 3. METHODS

For the study, the dape images of the materials M05, M08 and M15 were generated using the Cusick Drape Tester and simulated using the VStitcher software. Both results are evaluated in a subjective and visual image comparison. The calculation of the above-mentioned numerical parameters is the subject of a second study.

**3.1. Cusick Drape Test**

The Cusick Drape Tester (Cusick Drape Tester by James H. Heal in Halifax, United Kingdom), with which the drape images of the materials are created, is a recognised testing device for measuring the drape behaviour of textiles (2.). For subsequent image processing, the Drape Tester is coupled with a digital camera and the OBS software (Open Broadcaster Software, version 29.1.3) for image acquisition.

**3.2. Virtual simulation of the draping behaviour with VStitcher**

In addition, the draping behaviour of the materials is simulated virtually using the VStitcher® software (Version 2021.2.0 51910). For this purpose, the drape test according to Cusick was implemented in the simulation programme. In order to be able to generate comparable results, the test conditions were defined on the basis of the physical drape test [10]. These include the geometries of the test specimen and the specimens, parameters for positioning and fixing the specimen over the holding plate, settings for the virtual camera and lighting and specifications for rendering. In addition, a description of the test process ensures the reproducibility of the test procedure.
The material parameters required for the simulation are determined by Vizoo GmbH from Munich/Germany using FAB and made available digitally.

**3.3. Image processing for graphical representation with Adobe Photoshop CC 2023**

The image processing for analysing the digital drape images obtained with the Cusick Drape Tester and the digital drape images obtained in VStitcher is carried out with the image processing software Adobe Photoshop CC 2023. The digital colour images are converted to greyscale images and then to binary images so that the comparison can be displayed graphically. Automatic conversion of the drape images is useful for calculating numerical parameters (2.2). The MATLAB software (The MathWorks, Inc., version R2023a 9.14.0) will be used for this in a follow-up project.

**4. REALISATION**

**4.1. Cusick drape tester**

As described in 3.1, drape images of the selected materials are created using the Cusick Drape Tester. According to the standard, three different sample diameters are possible: 24 cm, 30 cm and 36 cm. After a preliminary test with a sample diameter of 30 cm, which did not provide any clear results with regard to the textile drape, all tests are carried out with a sample diameter of 36 cm. All materials are preconditioned under standard climatic conditions [5]. The marking of the centre point and warp direction allow the correct and comparable alignment of all samples and the evaluation with regard to the anisotropic material behaviour of textiles [5]. In deviation from the standard, only the right side of the fabric is tested, as it is not possible to differentiate between the right and left side of the fabric in the simulated drape test. The shadow image of the projected drop image is recorded with the evaluation software [5]. Figure 2 shows a picture of each of the tested materials.

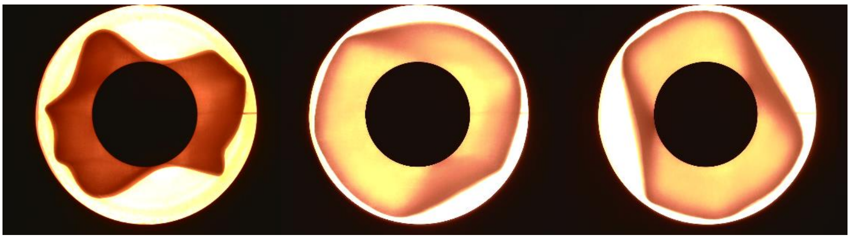


**Figure 9:** Draping images of materials M05, M08 and M15

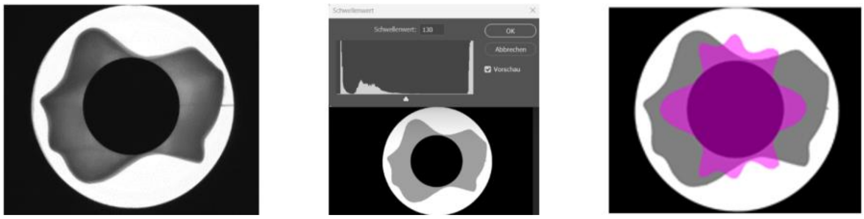
**4.2. Virtual simulation of the draping behaviour with VStitcher**

As described in 3.2, this is based on the previously described physical drape test according to Cusick. The three materials to be tested are implemented in VStitcher using the digital data previously determined with the FAB. The visibility of the support plate must be ensured for the image evaluation, which is why the transparency of the materials is set to 50%. The material behaviour is not affected by this.

**4.3. Comparative visualisation of the drape images with Photoshop**

The drape images are converted into binary images for better visualisation. The digital colour images consist of pixels, each of which is assigned a colour value. The conversion to binary images involves reducing the colours to black and white. In addition to the clear representation, the software can process these two colours as 0 or 1 and enable calculations based on the number of pixels (3.3). To create binary images, the colour images in Adobe Photoshop CC 2023 are first converted into grey scale images (Figure 3a). Regardless of the colours, the grey scale value represents the brightness of a pixel [21]. The threshold value is then determined (Figure 3b), which defines the brightness at which the pixel colour changes from black to white.

Figures 3a and b show the process for generating the binary images. To compare the drape images from the real test and the simulation, they are superimposed (Figure 3c). The draping image from the simulation is given a unique colour to clearly distinguish the two images.




(a) (b) (c)

**Figure 10:** (a) Binary image; (b) Threshold; (c) Overlaid drape test images from the real test and the simulation (grey - physical drape test; purple - virtual drape test).

## 6. RESULTS

The drape images from the physical and virtual drape test show the ability of textile fabrics to deform in multiple dimensions. In order to compare the results of the physical drape tests with those of the simulation, the categories number of waves, wave shape and wave position are used [22]. They form the basis for the characterisation of the drape patterns. The results for all three materials are shown in Figure 4.

### 6.1. Result for material M05

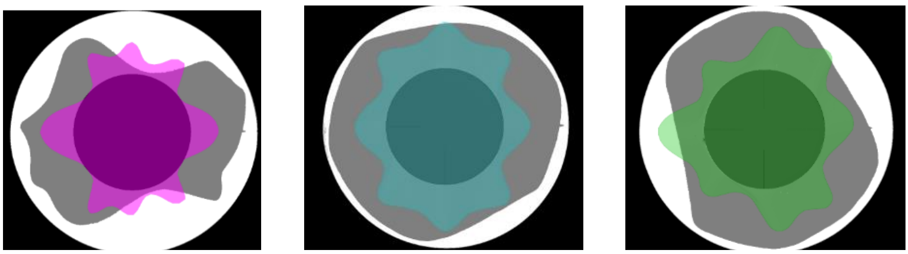
The image of the physical drop test for material M05 (Figure 4a, grey) shows pronounced waves in the contour. The material tends to undulate in the transverse direction. One wave is clearly pronounced at the top left. Seven waves can be counted along the contour. The waves are also more clearly recognisable in the simulated drape test (Figure 4a, magenta). Eight waves can be counted. Two clearly defined waves can be recognised in the transverse direction and three in the longitudinal direction. However, the position of the waves and the distances of the contour to the plate do not correspond to the drape image of the physical drape test; here the simulated material appears to be more flexible.

### 6.2. Result for material M08

The image of the physical drape test for material M08 shows hardly any waves along the contour, only slight flattening in the transverse direction (Figure 4b, grey). In the simulation, however, eight waves are clearly visible (Figure 4b, cyan). The position and shape of the waves is almost vertically and horizontally symmetrical. Three waves can be seen in the longitudinal direction and one wave in the transverse direction. The contours of the two overlap only once in the top centre and bottom right. Otherwise, the distances to the plate are shorter in the simulation.

### 6.3. Result for material M15

The drop image of the physical drape (figure 4c, grey) test shows a material concentration in the longitudinal direction with maximum distances between the contour and the plate. No clear waves can be recognised. Eight waves can be counted in the image of the simulated drape test (figure 4c, green). At the top left, the contours overlap; on the left, the contour of the simulation is much further away from the plate. The simulation does not reach the maximum distances to the plate of the drop image of the physical drape test. VStitcher simulates the material M15 much more flexibly than was found in reality.



(a) (b) (c)

**Figure 11:** Comparison of physical and virtual case images (a) M05, (b) M08, (c)

## 7. DISCUSSION

These visually and subjectively assessed comparisons clearly show that the simulation does not reflect reality. On the one hand, the materials are shown to be softer in the simulation. On the other hand, the anisotropic properties of textiles are not visible in the simulation. The material behaviour is reproduced almost symmetrically.

The application of the drape test shows the special deformation behaviour of textiles. Due to their inhomogeneous structure, which is characterised by the fibres, yarn and surface construction, a sample behaves differently in several tests with the drape tester and provides different drop patterns. This confirms the need to determine further parameters to describe the textile drape. Further investigations must therefore be carried out in order to be able to draw truly scientifically sound conclusions.

The comparison should be verified with numerical calculations of further parameters as described in 2.2 (2.2) These analyses can provide a better understanding and a more comprehensive and objective description of the drape properties of a material.

The Fabric Analyser (FAB) is a useful device for determining material parameters, particularly because it allows several properties to be tested in one operation. However, it should be noted that the device can only be used for Browzwear's own software. It is therefore advisable to develop the procedure for material testing with the FAB on the basis of standards in order to ensure comparability, traceability and reproducibility.

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