Links Between Cloth Design, Pattern Development and Fabric Behaviours

KRZYWINSKI, S.; SCHENK, A.; RÖDEL, H.; FISCHER, P.[1]
Institute of Textile and Clothing Technology
Dresden University of Technology
01062 Dresden
GERMANY *CSCC'99 Proceedings:*- Pages 4161-4165

1 Introduction

At present, the stage of product development and product preparation of clothes requires approximately three times the stage of consumption. In order to compensate the resulting greater efforts in the product preparation and to react more quickly and flexibly to latest fashion, the use of complex CAD - CAM solutions is a must. Today there are lots of existing design programs with various software tools and a wide choice of designing functions. Connected with sketching-systems so called two and a half dimensional presentation programs can give an optical impression how the colours, motifs and materials look on a scanned model. Steps of production preparation such as pattern construction, grading system, pattern planning and pattern optimisation and the automated cutting are realised by computer assistance. However, CAD-systems available on the market (with two exceptions – CDI, Asahi) show the following weak spots:

- the systems work only two-dimensionally
- the material behaviour and the material parameters are not taken into account.

Both these aspects are required for the three-dimensional display of a model with regard to the draping in order to give the designer and model maker a real impression of the model. Optimal possibilities to examine the correct fitting and the form of a model would be the three-dimensional display of a two-dimensional pattern construction on a dummy or a development of a three-dimensionally constructed model into the two-dimensional level, when the specific material parameters are taken into account. Consequently, the main focus in international research is to investigate the fundamentals of three-dimensional handling of fabrics. For that, a prerequisite is the implementation of algorithms for the simulation of draping of ready-made clothes. The specific material parameters such as the significant material parameters must be taken into consideration.

Therefore, the more detailed treatment of physical and mechanical properties and their correct mathematical and physical formulation is of interest. That's why a lot of experimental results with various woven fabrics were necessary. Investigations on the description of the material behaviour and of its properties are a further necessary focal point [1].

2 The Drape behaviour

The drape of a fabric has an outstanding importance for garment selection by customers. The acquisition is made by judging aspects of quality, fit and aesthetic appearance.

The behaviour of non-resistance of fabrics to bending without external force only under the influence of the true specific weight results in a three-dimensional deformation. For these deformations, the specific material properties of the fabric are decisive. A possibility to determine objectively the drape behaviour is the draping test (draping experiment) carried out using the drape meter developed by CUSICK [2] and the calculation of the resulting drape coefficient D in percent.

The drape image is characterised by the area, the form and amplitude of the folding, the number of folding and their position with regard to warp and weft direction.

According to CUSICK, the drape coefficient is defined by the surface relations of the drape image, the supporting disk and the surface of the cut. So far, many planimetring activities were required. The other characteristic features are not taken into account.

For the more efficient evaluation of the tests, the drapemeter measuring device was coupled with a video camera and image processing systems.

Hence, the previous subjective errors made when

---

[1] Saxon Textile Research Institute

measuring were minimised and the drape coefficient was determined within considerably less time. By image processing, new possibilities of evaluation of the drape image were created.

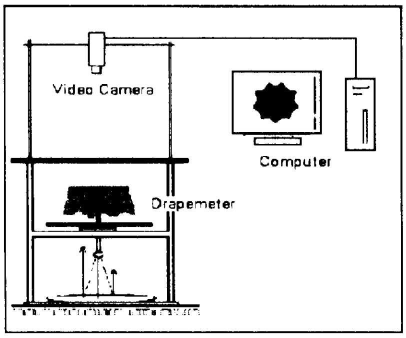


Figure 1: Draping Experiment with Video Camera and Image Processing System

Fabrics are classified on the basis of the drape coefficient. A high drape coefficient indicates a small deformation whereas a small drape coefficient marks great deformations. In our research work we used the Fourier analysis as an effective way to interpret the outline of the drape-shadows geometry. An appropriate program was developed. Furthermore it's possible to get information about the drape geometry by evaluating the Fourier coefficients, like the amplitude and number of waves and the curvature of wavelines [3].

2.1 Fourier analysis

To analyse the outline of the drape-shadows geometry, it's necessary to determine the points of the boundary curve in a distance of 3 degree, so n = 120 points along the curve are available (Figure 2).

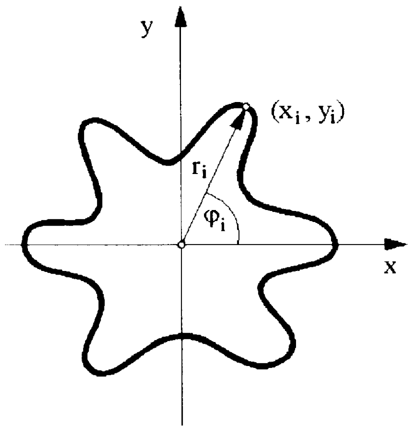


Figure 2: Determination of the Boundary Curve

The points of the image with their determined coordinates (radius r_i and angle φ_i with i=1,...,n) are the nodes for the Fourier expansion. The approximation of the boundary curve is realised with the approach

$$r=f(\varphi)=\frac{a_0}{2}+\sum_{k=1}^{\frac{n}{2}-1}[a_k\cos(k\varphi)+b_k\sin(k\varphi)]+\frac{a_{n/2}}{2}\cos(\frac{n}{2}\varphi) \quad (1)$$

The function $f(\varphi)$ consists of the partial sums of the sinus terms and the cosines terms. The Fourier coefficients a_k and b_k with

$$a_k=\frac{2}{n}\sum_{i=1}^{n}r_i\cos(k\varphi_i) \text{ and } b_k=\frac{2}{n}\sum_{i=1}^{n}r_i\sin(k\varphi_i) \quad (2)$$

are the amplitudes of the partial waves (vibrations) or rather Fourier orders.

2.2 Calculation of the drape coefficient

By means of double integration of the Fourier series over the angle φ from 0 to 2π it is possible to determine the surface of the drape image:

$$A=\int_0^{2\pi}\int_0^{f(\varphi)} r\,dr\,d\varphi$$

$$=\int_0^{2\pi}\frac{1}{2}f^2(\varphi)\,d\varphi \quad (3)$$

$$=\frac{a_0^2}{4}\pi+\sum_{k=1}^{\frac{n}{2}-1}(a_k^2+b_k^2)\frac{\pi}{2}+\frac{a_{n/2}^2}{8}\pi.$$

2.3 Determination of the number of waves

The Fourier coefficients of all terms are a complete mathematical description of the analysed boundary curve of the drape image. The terms with the Fourier coefficients a_k and b_k could be described by the addition rule:

$$a_k\sin(k\varphi)+b_k\cos(k\varphi)=c_k\cos(k\varphi+\psi_k) \quad (4)$$

with

$$c_k=\sqrt{a_k^2+b_k^2} \quad \text{and} \quad \psi_k=-\arctan\left(\frac{a_k}{b_k}\right). \quad (5)$$

After sorting the c_k -terms of the Fourier series the Fourier order with the highest influence is defined and also the number of waves are determined.

k	Fourier coefficients a_k	b_k	c_k	angle y_k
9	-1,21	9,79	**9,87**	10,78
7	0,79	4,16	4,24	11,31
8	-1,25	-3,84	4,04	31,49
10	-1,44	3,72	3,99	11,11
5	0,39	2,31	2,35	16,08
11	0,40	-1,57	1,62	25,84
6	-1,45	0,03	1,45	29,83
2	-1,40	-0,07	1,40	91,41
4	-1,13	-0,47	1,22	50,59

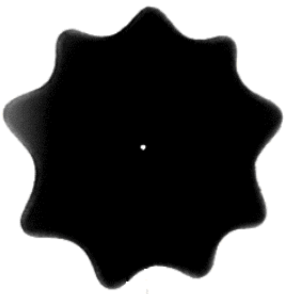


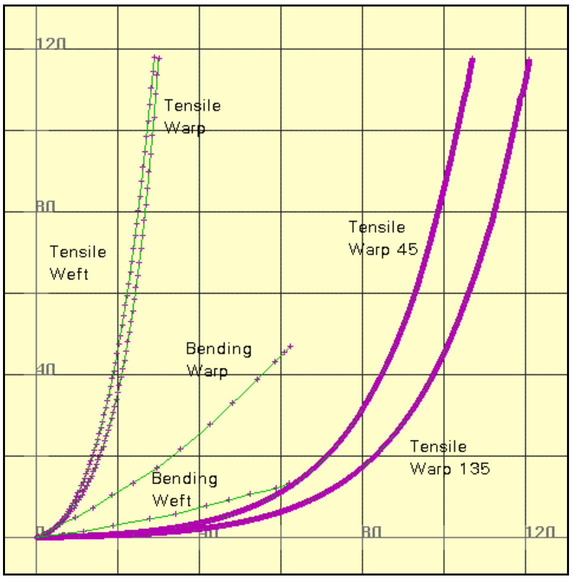
Figure 3: Fourier Coefficients of a Drape Image of Sample 1

3 Three-dimensional display of two-dimensional pattern

The current procedure to create patterns is a multi-step approach which involves too much personnel, time and costs due to the trial and error phase. The fabric properties enter the design process only via expertise of designers. It is absolutely necessary for CAD-systems to be extended with material parameters and to search for possibilities to connect design and pattern construction in the future.
The objective of the research is to create a complete CAD-system for garment manufacturers including 3D-visualization of garments on virtual human beings. An excellent CAD-system for the clothing industry should comprise the following modules:

- fabric library relating easy to determine fabric properties to fabric drape configurations; search and sorting routines should be integrated in the library for easy use;
- model for the human body, which can be adapted for persons of different sizes;
- routines to simulate garment patterns from specific fabrics on the human body with use of data of the fabric library.

The following figures, which was made using 3D-Concept by CDI Technologies Ltd., give an impression of this subject.



The scale of the property curves depends on the measurement devices (for example KES, Cantilever, Zwick).
Figure 4: Fabric Properties

In this program the bending properties in warp and weft direction, the tensile properties in warp, weft , 45 degree warp and 135 degree warp direction and also the weight per unit are considered in the draping module.

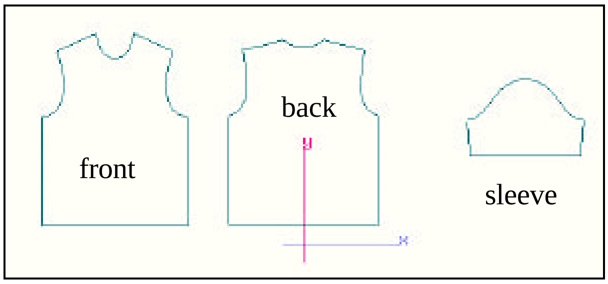


Figure 5: Two Dimensional Pattern

Companies developed 3D-body-scanners where the three dimensional perception of the human body can be realised with a sensor system in a fast and objective way. Some garment manufacturers already use these systems as a tool to define the correct cut-pattern of fabrics for example for men’s clothing manufacturing.

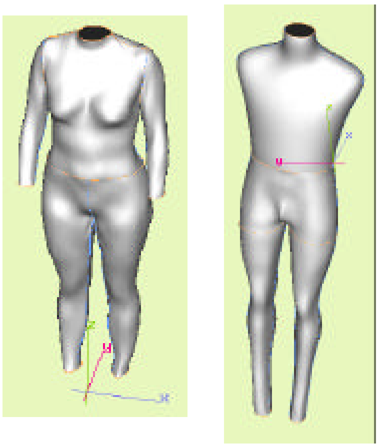


Figure 6: Human Body

The 3D-Concept enable the user to seam 2D pattern pieces together and drape them over a 3D model. Therefore it is necessary to prepare the 2D pattern piece. Guidelines are used to anchor special lines (for example neckline, waistline) to the 3D body and seam points match different pattern pieces (Figure 7). The next step is to place the 2D-mesh into the 3D space near the 3D body, from witch the draping process starts (Figure 8). After this from the draped mesh (Figure 9) the user have to generate a surface.

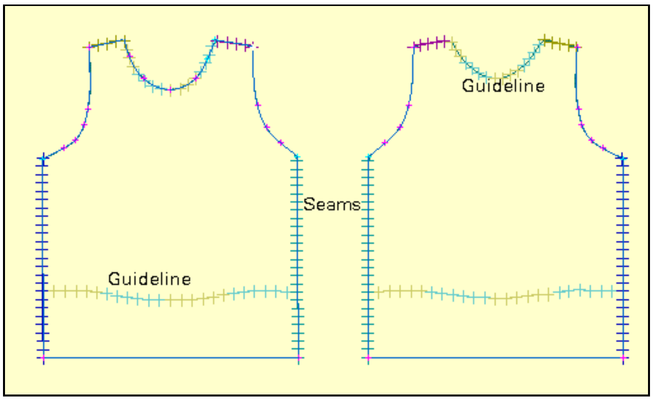


Figure 7: 2D-Pattern with Guidelines and Seams

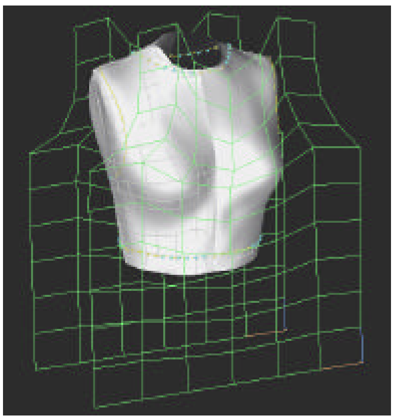


Figure 8: Start Position

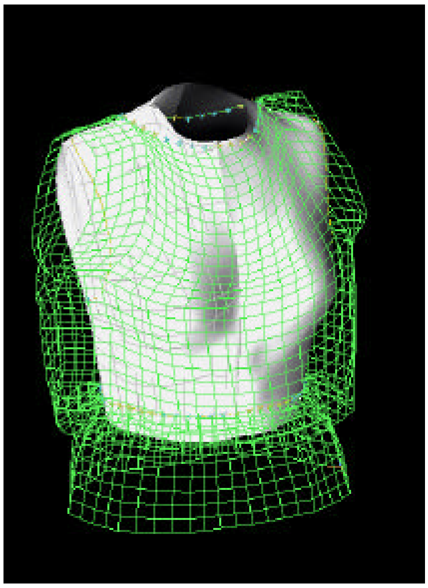


Figure 9: Draped Mesh

Unfortunately the result of the simulation of these very simple patterns shows, that the different fabric properties are considered but the quality of the simulation is not good enough for the industry (Figure 10-12). Besides in practice this results are not usable because of the fact, that the 2D pattern pieces normally are much more complicated.
Also a disadvantage consists in the high and expensive hardware demands and in long calculation times (in some cases up to some hours). Therefore it is necessary to develop those tools with high functionality and with low configuration demands and price and also easy handling.

Table 1: Material Parameters

properties	sample 1
material	PES 55 / WO 45
weave	twill
thread density [number/dm]	D_k=282, D_s=254
thread fineness [tex]	Tt_k/Tt_s=33,3
mass per unit [g/ m^2]	m_A=280
bending stiffness [10E-5 Nm]	B_k=0.75, B_s=0.68
tensile (linearity)	LT_k=0.51, LT_s=0.54
drape coefficient	F=0.46

Figure 10: Draped Surface of Sample 1

Figure 11: Sample 1 with lower Bending Stiffness in Weft Direction

Figure 12: Sample 1 with higher Bending Stiffness in Weft Direction

That's why it is the aim of an interdisciplinary research project of the Institute for Textile and Clothing Technology and the Institute for Mechanics at Dresden University of Technology to describe and simulate the drape behaviour of flexural fabrics (especially of woven fabrics). The three-dimensional description of the drape based on the idea of the minimum of the potential energy which is formulated by means of the simulation model presented in [1, 4, 5 ,6 ,7]. In this model isotropic material behaviour with the bending stiffness and the weight per unit are considered. It is in good coincidence with the experiment concerned. It can be stated that when compared with FEM and other CAD-systems, a minimum of independent values is sufficient to reach an efficient basic approach of the problem. So very much calculation time can be saved with this method. Present in frame of a new project we try to improve the reached results by means of a better approach with the consideration of orthotropic material behaviour and additional strains.

References

[1] Magloth, A.: Design-Idee und Materialverhalten als Gestaltungseinheit", *Bekleidung & Wear*, 20/97, pp. 13-14

[2] Cusick, G. E.: The Measurement of Fabric Drape, *Journal of the Textile Institute*, Vol. 59 (1968) 6, pp. 253-260

[3] Fischer, P.: Ermittlung der mechanischen Kenngrößen textiler Flächen zur Modellierung des Fallverhaltens unter Berücksichtigung konstruktiver, faserstoffbedingter und technologischer Abhängigkeiten, *Dissertation TU Dresden*, 1997

[4] Schenk, A.: Berechnung des Faltenwurfs textiler Flächengebilde, *Dissertation TU Dresden*, 1996

[5] Rödel, H., Ulbricht, V., Krzywinski, S., Schenk, A., Fischer, P.: Simulation of drape behaviour of fabrics, *Conference Proc. „Advances in Fibre and Textile Science and Technologies"*, Mulhouse, 1997

[6] Brummund, J.; Schenk, A.; Ulbricht, V.: Beitrag zur Modellierung des Fallverhaltens in der Textilindustrie, *Proceedings GAMM* 1998, Bremen, Germany

[7] Rödel, H.; Ulbricht, V.; Krzywinski, S.;. Schenk, A.;. Fischer,P.: Simulation of Drape Behaviour of fabrics, *International Journal of Science and Technology*, Vol.10, No.3/4, 1998, pp. 201-208