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Modelling the Fused Panel for a Numerical Simulation of Drape

Abstract
The end form of produced cloth depends on the qualities of the build material and its construction requirements. These can be estimated subjectively or objectively after the cloth is finished. The drape of the fabrics and the fused panel is one of the most significant properties which characterise the shape of produced cloths. Investigating the behaviour of a fused panel as a connective composite during drape is very difficult, as its geometrical structure and material nonlinearity are complicated. This paper presents the use of the finite elements method for modelling a fused panel drape. The mechanical model of a fused panel is based on the laminate theory. Comparisons between the experimental and simulated drapes of a fused panel described by visual pictures and parameters are important for describing the aesthetic shape of clothes, i.e. drape coefficient, drape fold number, fold depth, maximum and minimum hang. The results of numerical analysis of fused panel drape which were obtained show significant promise for the additional development of research regarding the computer simulation of the behaviour of produced cloth.

Key words: *fused panel, drape, finite elements, clothing engineering.*

Introduction

The shape of a produced garment depends on the garment construction and the material incorporated. During the design process, many problems concerning the choice of suitable material arise because it must conform to the shape of the designed cloths. From this point of view, the end form of produced cloth depends on the properties of all the incorporated materials, i.e. the kind of shell fabric and auxiliary materials such as lining, fusible interlining, thread and so on, and their consequences. The most important incorporated component of clothes is the fusible interlinings. These are usually invisible because they lie hidden between the shell fabric and lining, but on the other hand their properties have a great influence on the shape, appearance, softness and durability of the clothes.

When investigating the behaviour of shell fabric while producing cloth, the last stage is the extensive investigation theme [1-4]. In the electronic business of clothes sales, the subsequent progress can be simulated by a virtual presentation of the clothing. Most problems that experts encounter when planning a virtual presentation at a fashion show is how to assimilate the real behaviour of all the incorporated materials into a working model of the clothes. Shell fabrics play the most important roles. The problem is that fabrics are nonlinear and nonhomogenous materials, and they undergo considerable deformation as a result of small externally applied forces [1-4]. Unfortunately, assessing the behaviour of cloths and their special deformation on the human body by simple recognition, touch and feel is very difficult to achieve from the engineering viewpoint. All previous researchers and engineers have had the same aim; to construct a computer model of the fabric which would behave realistically in regard to human wearing, but only achieved an imitation of its behaviour [1,5,6,].

The Behaviour of Fused Panels and Their Influence on Produced Cloths

Normally the shell fabrics have nonhomogeneous properties throughout the whole surface, and can therefore be fused with fusible interlining. The basic characteristics of fusible interlining are the type and structure of the supporting material as a substrate, and the type and deposit of the adhesive. The types and the structures of the supporting material determine the mechanical properties of the fusible interlining, and they have a high influence on the final applicable properties of the fused panels.

If the shell fabric is the component that directly influences the appearance of a cloth, then the fusible interlining is the component that improves the aesthetic and applicable properties of the cloth.

Estimating the quality of a fused panel is a very complex task, because it is necessary to consider the consequences of any interactions of the entire components with the different mechanical and physical properties. Very often the quality of fused a panel is estimated by using bond strength, mechanical properties like extensibility, shear and bending properties, dimensional stability after fusing, washing or chemical cleaning, and then surface appearance and ability to form into 3D. The bond strength can be estimated by measuring the force required to separate the interlining and shell fabric. The mechanical properties are established with the FAST and KES-FB measuring systems, and the dimensional stability can be established by the FAST-4 testing method or any other standard testing method.

The 3D shape of a fused panel is estimated to be the same as for shell fabric. It could be subjective or objective [7]. Investigating the 3D behaviour of the fused parts of clothes is very important, and is one of the basic criterion for evaluating the shape of produced garments. It can be evaluated on the basis of formability and drapability.

The formability of a shell fabric is defined as its ability to re-form from a two-dimensional shape to a simple or complex three-dimensional shape [8,9]. Drapability is a phenomenon which arises when a fused panel or shell fabric hangs down over a circular pedestal without the use of external force. The characteristic examples in practice that can describe drape are how a curtain hangs, how a fully flared skirt looks, how a tablecloth drapes over the table, and so on. Fabric drape is directly related to aesthetics, which is important for the development of new kinds of shell fabrics as well as for the design of new clothes. The draping evaluation of shell fabric can be subjective. In this case particularly, the expert designers need a great deal of experience in the textile area, because this is done using the senses of sight and touch. Another way of objective drape evaluation is based on experimentally measuring the variety of drape parameters, i.e. drape coefficient, depth of folds, number of folds and distribution of folds. Different measuring equipment can be used for this purpose [5,10,11].

Drape coefficient describes any deformation between deformed and non-deformed fabrics (Figure 1). It is a given percentage of the ring area between radius R_2 of the fabric and radius R_1 of the disc holding the fabric which is covered by the projected shadow, and it can be determined by [11]:

$$CD = \frac{S_p - \pi R_1^2}{\pi R_2^2 - \pi R_1^2} \tag{1}$$

CD - drape coefficient;
S_p - projection area of draped specimen, mm^2, including the part covered by the horizontal disc;
R_1 - radius of horizontal disk, mm;
R_2 - radius of non-deformed specimen, mm, according to Figure 1.

The interpretation of drape coefficient value is connected with the number, form, amplitude and distribution of folds and their positions according to weft and warp direction. The high value of drape coefficient means that the fabric is stiff and could therefore be difficult to re-form. Alternatively, a low value of drape coefficient means easier reform, and at the same time better adaptation of fabric to the shape of the cloth. The shape and number of folds are dependent on fullness and fabric stiffness. A fabric with higher stiffness has larger and wider folds, and less stiff fabrics have narrower folds [5,12].

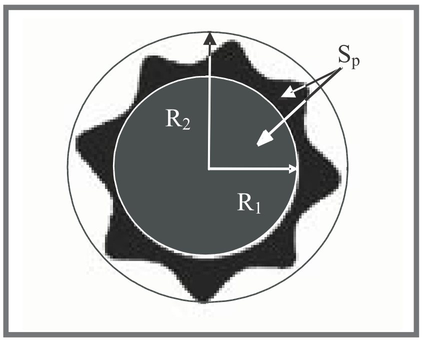

Figure 1. *Determination of drape coefficient.*

The next parameter is folding distribution G_p. It is calculated as a normalised variance of the maximum fold from the average maximum fold length. It indicates how balanced or even the folds are [5].

$$G_p = \sum_{i=1}^{n} \frac{\left(l_{G_{\max}}(i)\bar{l}_{G_{\max}}\right)^2}{\bar{l}_{G_{\max}}^2} \tag{2}$$

$$\bar{l}_{G_{\max}} = \sum_{i=1}^{n} \frac{l_{G_{\max}}(i)}{n} \tag{3}$$

$$\bar{l}_{G_{\min}} = \sum_{i=1}^{n} \frac{l_{G_{\min}}(i)}{n} \tag{4}$$

where:
G_p - folding distribution,
$\bar{l}_{G_{max}}$ - the average of the maximum depth of the folds,
$\bar{l}_{G_{min}}$ - the average of the minimum depth of the folds,
$l_{G_{max}}(i)$ - the maximum depth of the fold,
$l_{G_{max}}(i)$ - the minimum depth of the fold.

Modelling the fused panel as a laminate

The geometrical aspects of fused panels are constructionally comparable to laminated materials [14]. A fused panel can be treated as a two-layer laminate; one lamina is shell fabric and the other lamina is the fusible interlining. The adhesive represents the medium of load transfer between the fusible interlining and shell fabric.

The lamina is composed of different fibres that are connected mechanically, chemically and thermically in the matrix. The types and orientation of fibres and the sort of matrix form the basis of the single lamina's mechanical properties. The fibres in the laminate may be continuous or of short length, and can be aligned in one or more directions, or randomly distributed in two or three dimensions [15]. Both the shell fabric and the fusible interlining are composed of weft and warp threads, and their mechanical properties depend on the kind of weaving. They can thus be compared with lamina or matrix (Figure 2).

Furthermore, the laminate is composed from different numbers of lamina, orientated arbitrarily to each other. The properties of the laminate depend on the number of lamina and the orientation of the individual lamina. The end effect of fusing processes is also dependent on the orientation of shell fabric and of the fusible interlining. The fused panel has the properties of a two-layer laminate after the fusing process, when the adhesive is distributed into the shell fabric and the fusible interlining, and so presents a matrix composed of weft and warp threads and an incorporated adhesive.

Application of the finite element analysis in a textile area

The finite element method belongs to the methods of numerical analysis, and is based on the usage of matrix algebra. Solving these problems is based on the digitisation of arbitrary construction into suitably finite elements. This method is developing today as a special scientific discipline with very wide possibilities for solving different problems in areas such as mathematics, physics, continuum mechanics, and so on. More and more applications can be found in the textile area. The development of programs for solving nonlinearity problems has produced very satisfactory results, as in cases when large displacements and small deformation appear which are significant for a shell fabric.

Collier et al. were the first to use the finite element method by modelling fabric drape [2]. The fabric was described as two-dimensional, orthotropic materials with linear properties. They used Young's and shear modules values obtained from measurements performed with use of the KES FB system for calculation in warp and weft direction, whereas the values of Poisson's ratio were based on literature data. The calculated drape coefficient was analysed by experimental measurement using a Cusik drape meter.

Drapability over a square table was analysed by Govindaray using the finite element method [3]. He studied the draping behaviour of fabrics by using a non-linear finite element method based on a classical non-linear plate theory.

J. Hu et al. developed a geometrically nonlinear finite-volume method for the numerical simulation and analysis of a fabric drape [16]. An initially flat circular fabric sheet is first subdivided into a number of structured finite volumes by mesh lines along warp and weft directions, resulting in rectangular internal volumes and triangular or quadrilateral boundary volumes. The authors discovered that the proposed finite volume method is capable of predicting not only the basic deformed shape of the fabric over a circular pedestal, but also other possible drape patterns in different actual experiments.

Large deformation and rotation as a small strain characteristic of a fabric was investigated by D.K.C. Yu using numerical calculations [17]. He modelled the fabric using plate and shell elements, and the "Alpha" constant stiffness matrix iterative method was used to reduce simulation time. The advantage of this method is that less computation time is required, but the disadvantage is that the degree of the non-linearity in the drape problem was incompletely represented by the unknown coefficient matrix during iteration.

Methodology

This present study considers the draping and forming of a fused panel using finite element methods. The aim of this investigation was to construct a model of a fused panel for the numerical simulation of drape. The results obtained are compared with the experimental measuring on the basis of drape parameters and visual estimation of a draped fused panel's final appearance.

Two wool fabrics for upper clothes fused with three different suitable fusible interlinings were used to investigate the drapability of the fused panels. The list of shell fabric and fusible interlining properties are given in Tables 1 and 2. The fusing parameters were chosen according to the recommendations of a fusible interlining producer and previous testing on a Meyer RPS-L40 continuous fusing machine. The mechanical properties of the materials were determined using the KES-FB, and the Poisson ratio was determined on a tensile meter developed in the Laboratory of Clothing Engineering in Maribor.

Table 1. *Properties of fabrics.*

Fabric code	Linear density of:		Fabric density		Weave	Weight W_t, g/m²
	Warp T_{to}, tex	Weft T_{tv}, tex	Warp g_o, thread/cm	Weft g_v, thread/cm		
SF-1	14.29	14.29	40.30	22		200
SF-2	14.29	14.29	30.24	23		218

Figure 2. *Comparison between the fused panel and two layer laminate.*

Research model

The investigation of fused panel drape was divided into experimental measuring, modelling the fused panel and numerical simulation (Figure 3).

Experimental work

In the framework of the experimental part, the rheological parameters necessary for constructing the numerical model of fused panel were first carried out: i.e. Young's, shear modulus and Poisson's ratio of shell fabrics and fusible interlinings. The measurement of fused panel drape on the Cusik drape meter was also carried out within the experimental work. The Cusik drape meter is composed of a video camera and the Drape Analyser programme packages. For this purpose, the sample was cut within a radius of 300 mm and put on a horizontal pedestal within a radius of 180 mm. The circular piece of the sample (60 mm) was draped over a pedestal, and deformation arises in the form of folds. The following parameters were determined by means of a drape meter: drape coefficient, number of folds, minimum and maximum amplitude and the length between folds. Furthermore, the additional drape parameters were also calculated from the measured data (Figure 4):

- maximum hang of fabric sample f_{max} can be expressed as:

$$f_{max} = \sqrt{p^2 - (l_{G_{min}})^2} \tag{5}$$

- minimum hang of fabric sample f_{min} can be expressed as:

$$f_{min} = \sqrt{p^2 - (l_{G_{max}})^2} \tag{6}$$

- the depth of fold d_G, can be expressed as:

$$d_G = l_{G_{max}} - l_{G_{min}} \tag{7}$$

All measurements were carried out under standard testing conditions (20 ± 2°C and 65 ± 2% RH).

Mechanical model of a fused panel

The mechanical model of a fused panel is defined with the rheological parameters of the shell fabrics and fusible interlining. This fused panel model was designed on the theoretical basis of laminated materials [15]. The fused panel was treated as a layer laminate joined from two lamina; shell fabrics and fusible interlining. Each component has its own properties connected by adhesive. Furthermore, although the shell fabrics in fusible interlin-

Table 2. *Properties of fusible interlinings ([1]CP-computer pointed).*

Code of fusible interlining	Parameters								
	Raw material	Weave	Weight W_{fl}, g/m²	Fabric density		Linear density of:		Adhesive type	Amount of adhesive W_a, g/m²
				Warp g_o, thread/cm	Weft g_v, thread/cm	Warp T_{to}, tex	Weft T_{tv}, tex		
FI-1	68% PES 32% CV	Warp knitted fabric	79	11	12	5	36	PA CP[1] 52	11
FI-2	100% Co		88	24	13	20	20	PA CP 52	9

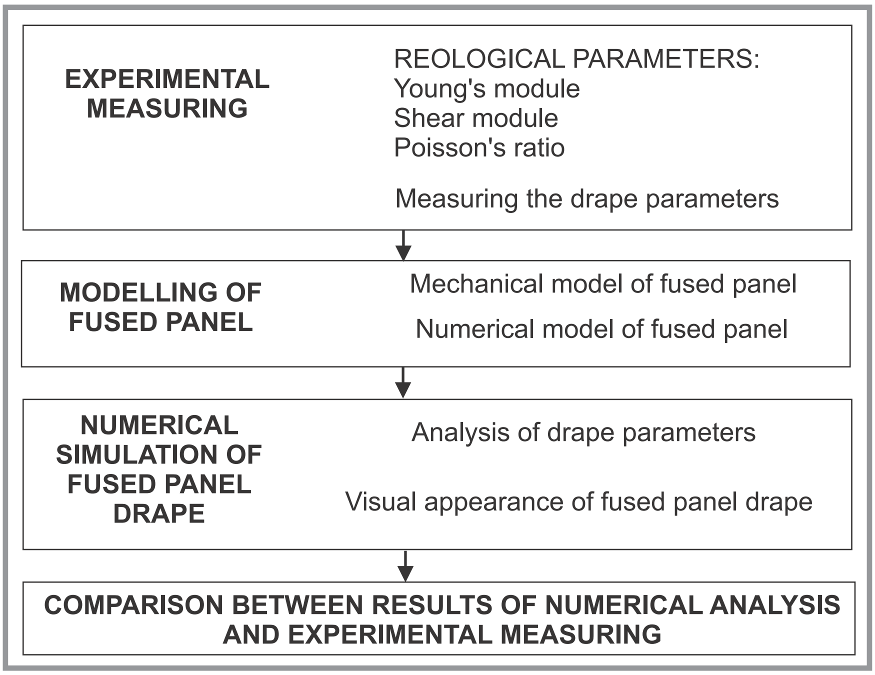

Figure 3. *Research model of fused panel drape.*

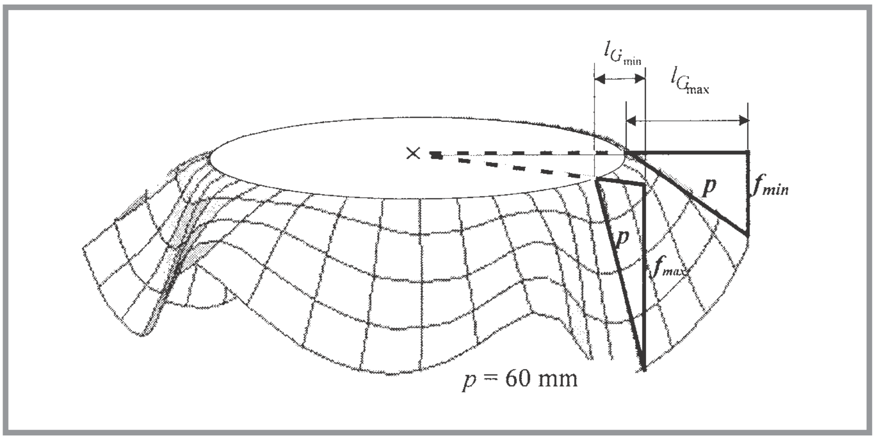

Figure 4. *Maximum and minimum hang of fabric.*

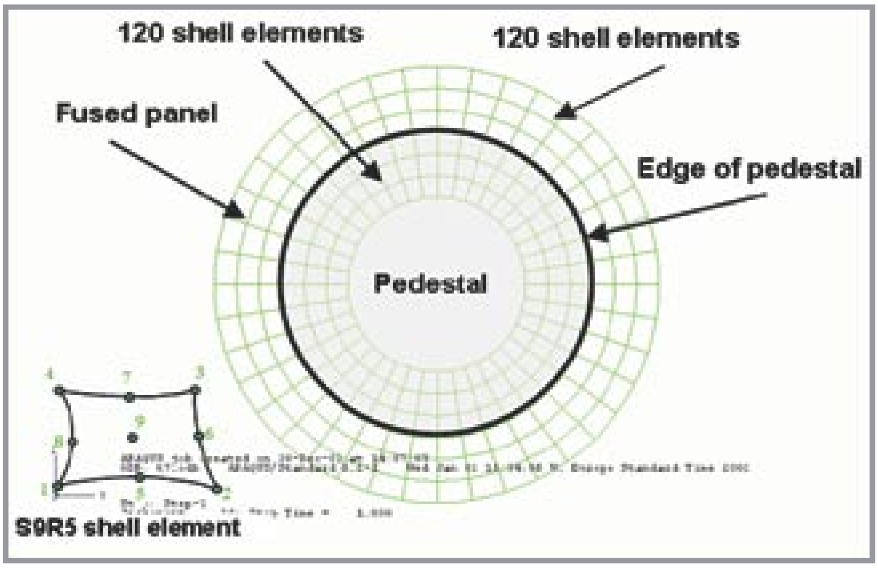

Figure 5. *Digitisation of model for testing the fused panel drape.*

ing have non-homogenous and anisotropic local characteristics, it was assumed for the fused panel's mechanical model that it is a continuum with homogeneous and orthotropic properties. Its structure can be described using the following rheological parameters: Young's and shear modulus in a warp and weft direction and Poisson's ratio. The thermoplastic connection between the shell fabric and the fusible interlining creates the matrix of connection into the fused panel. The formed connection is non-homogenous in all areas because the thermoplastic resin is distributed pointwise on the base fabric. Without regard to the above mentioned characteristics of the fused panel connection, it is supposed that it has a uniform arrangement over the whole area. This means a uniform density at the connection points with negligible thickness and average size and quality of connection at the applied places.

Numerical model of fused panel drape

The numerical model of the fused panel drape was constructed using shell finite elements. The following suppositions for numerical modelling were considered: that the fabric is a continuum with homogeneous and orthotropic properties, and the fabric's behaviour within low loading is linear. The numerical model for numerical analysis of drape was constructed on the basis of the Cusik drape meter method. The drape model had been digitised with 240 elements. The thin 3D shell elements marked S9R5 were used for this purpose. The ABAQUS program package for numerical analysis was used [18]. Those parts of the samples which draped outside over the pedestal were described by 120 finite elements, and the remaining 120 elements described the sample lying on the pedestal (Figure 5). The model was observed under the load of its own weight. Newton-Raphson's iterative method for equations solving was used.

Results

On the basis of the research model for modelling a fused panel drape, the results obtained can be presented in the following form:

- determination of rheological parameters,
- the results of experimental of measuring the parameters of the fused panel drape,
- a comparison of the numerical and experimental results of the fused panel drape.

Table 3. *Rheological parameters of analysed shell fabric and fusible interlining.*

Code of sample	E_o, N/mm²	E_v, N/mm²	G_o, N/mm²	G_v, N/mm²	ν_o	ν_v
SF-1	12.27	8.59	0.084	0.086	0.19	0.10
SF-2	14.39	2.19	0.107	0.104	0.22	0.13
FI-1	8.07	1.54	0.076	0.056	0.23	0.13
FI-2	10.77	5.38	0.055	0.055	0.24	0.12

Table 4. *Experimentally obtained drape parameters of fused panels.*

Measured / calculated parameters		Samples code											
		FP-1			FP-2			FP-3			FP-4		
Measuring		1	2	3	1	2	3	1	2	3	1	2	3
Drape coefficient	-	0.56	0.52	0.53	0.68	0.68	0.69	0.61	0.58	0.59	0.71	0.72	0.71
Number of folds	-	7	7	8	6	6	5	7	7	7	6	7	6
Maximum hang	mm	56.31	57.45	56.77	51.72	52.01	51.78	52.35	53.63	53.06	50.75	50.17	50.62
Minimum hang	mm	27.93	29.22	31.60	26.15	26.76	26.76	23.51	29.04	25.56	21.01	21.01	23.74
Depth of fold	mm	32.40	35.10	30.60	23.60	23.80	19.50	25.90	25.60	25.80	24.20	23.30	22.90
Maximum amplitude	mm	143.1	142.4	141	144.0	143.7	143.7	145.2	142.5	143.8	146.2	122.9	145.1
Minimum amplitude	mm	110.7	107.3	109.4	120.4	119.9	124.7	119.3	116.9	118.0	122.0	146.2	122.2

Table 5. *Drape parameters of the fused panel achieved using numerical analysis.*

Measured / calculated parameters		Sample code			
		FP-1	FP-2	FP-3	FP-4
Drape coefficient	-	0.61	0.72	0.65	0.75
Number of folds	-	6	6	6	6
Maximum hang	mm	45.33	48.82	44.10	41.80
Minimum. hang	mm	23.63	22.94	22.16	21.20
Depth of fold	mm	37.40	24.30	19.30	25.20
Maximum amplitude	mm	139.50	140.10	149.00	149.40
Minimum amplitude	mm	102.10	115.80	119.70	124.20

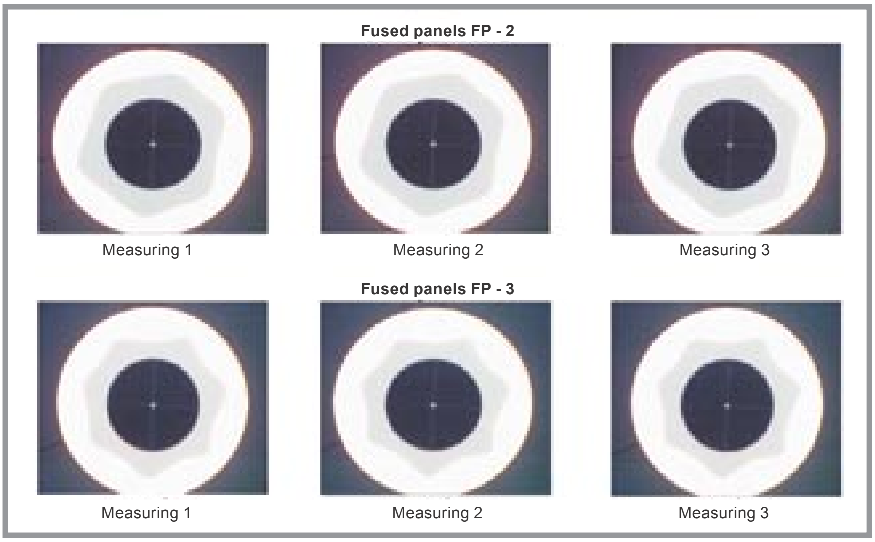

Figure 6. *Experimentally obtained drape shape of fused panel.*

Determination of rheological parameters

The results of experimental research for determining the rheological parameters of the shell fabric and fusible interlining required for the mechanical model of a fused panel are given in Table 3. The Young (E_o, E_v) and shear modulus (G_o, G_v) were determined using the KES-FB system, but the Poisson ratio (ν_o, ν_v) was experimentally measured on a tensile meter.

The results of experimental measuring the parameters of fused panel drape

The experimental results of the fused panel drape carried out from the testing equipment (Cusik drape meter) are presented in Table 4, while Figure 6 represents the experimentally obtained drape shapes of the fused panels referred as FP-2 and FP-3. Each example was measured three times.

The results of numerical simulation of fused panel drape

The results obtained with numerical simulation of fused panel drape are presented in Table 5, while Figure 7 represents the numerically obtained drape of fused panel shape for the examples referred as FP-3 and FP-2.

Figure 7 shows the vertical projection and lateral sight of the simulated drape shapes of fused panels FP-2 and FP-3. Both appearances were chosen; firstly the vertical projection was compared with the experimentally obtained shape of the drape, and secondly, the lateral sight of the simulated drape showed one of the possible advantages offered by the numerical planning of fabric behaviour as well as the fused panel. The drape parameters of the fused panel obtained by numerical simulation using the ABAQUS programme package are given in Table 5.

Discussion

The numerical analysis of fused panel drapability which we present is designed for investigating the behaviour of shell fabric and the fused panel regarding the end shape of the produced garment. Drapability was analysed as a comparison between experimental and numerical results according to the theoretical foundation considered for modelling fused panel drape using the finite element method, and these results refer to drapability coefficient, number of folds, and the maximum and minimum hang

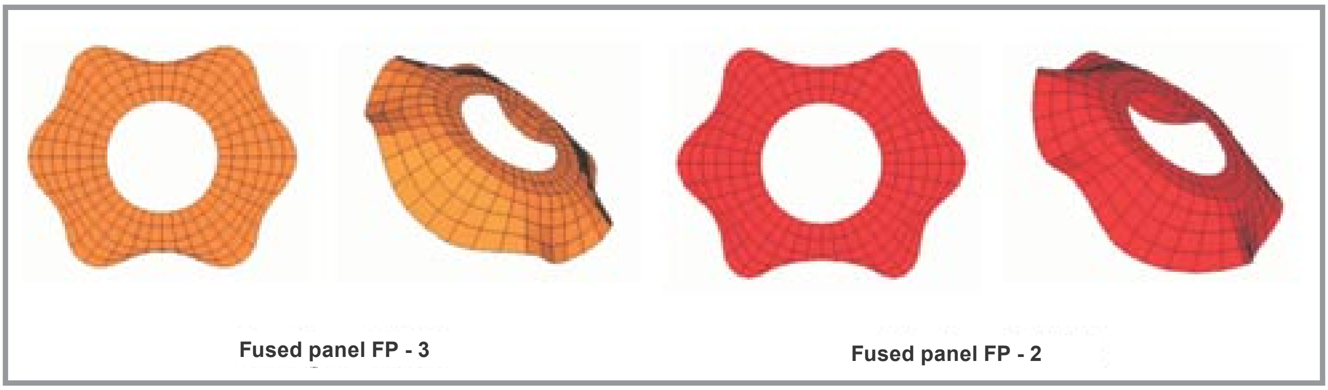

Figure 7. *The numerical simulation of the fused panels.*

and depth of folds. An analysis of the achieved results (Figures 6 and 7) shows the similarity in drape form between the fused panels FP-2 and FP-3 according to experimental drape using the Cusik drape meter and the numerical simulation of the ABAQUS program package. It can be seen that the drape shape after the each of the three repeated experiments is never the same. Therefore it is unrealistic to expect that the drape shape of the computerised simulation would be completely identical with the experimentally obtained shapes. Furthermore, it was assumed in the numerical model that the fused panel has orthotropic properties; therefore, the simulated drape form is symmetrical. This is opposite to the realistic drape behaviour from the experiment, because the fused panel is anisotropic. Experimental measuring also showed the non-symmetrical arrangement of the folds which is a consequence of the locally non-homogenous structure of the fused panel. On the other hand, the obtained results of minimum and maximum hang and depth of folds between numerical simulation and experimental measuring showed good agreement. (Tables 4 and 5).

Figures 6 and 7 also give a visual comparison of a deformed fused panel. In all numerical simulation, it can be seen that the behaviour of the fused panel is essentially stiffer. After this analysis, it was established that the reason is in the accession of modelling the connection between shell fabric and fusible interlining because it was supposed that they have uniform structural density at the connection point with hardly any thickness.

Conclusion

This study presents a manner of modelling fused panels for numerical analysis of their drape. The developed fused panel model for drape analysis is simple and it is computationally efficient. The results for the numerical simulation of a fused panel in comparison with experimental measuring confirm the applicability and reasonableness of the finite element method for investigating the fused part of produced cloths. In the future, such a model could have a great importance in the field of computer-based planning of the properties of shell fabric and fusible interlining, as well as the observation of real behaviour of produced cloths.

References

1. Breen, D.E., House, D.H., Wozny, M.J. (1994): A Particle-Based Model for Simulating the Draping Behaviour of Woven Cloth. Textile Research Journal, 64 (1994) 11, pp. 663-685.
2. Collier, R., Collier, B. J. (1991): Drape Prediction by Means of Finite Element Analysis. Journal of Textile Institute, 82 (1991) 1, pp. 96-107.
3. Chen, B., Govindaraj, M. (1995): A Physically Based Model of Fabric Drape Using Flexible Shell Theory. Textile Research Journal, 65(1995)6, pp. 324-329.
4. Chen, B., Govindaray, M. (1996): A Parametric Study of Fabric Drape. Textile Research Journal, 66(1996)1, pp. 17-24.
5. Stylios, G.K., Zhu, R. (1997): The Characterisation of the Static and Dynamic Drape of Fabrics. Journal of Textile Institute, 88 (1997) 4 pp. 465-475.
6. Stylios, G., Powell J., Cheng L. (2000): An Investigation into Engineering of the Drapability of Fabric. 3rd International Conference IMCEP'2000, Innovation and Modelling of Clothing Engineering, Faculty of Mechanical Engineering, Maribor, 1997, pp.88-95.
7. Stylios, G.K., T.R. Wan. (1991): The Concept of Virtual Measurement 3D Fabric Drapability. International Journal of Clothing Science and Technology, 11 (1999) 1, pp. 10-18.
8. Lindberg, J., Waesteerberg, L., Svenson, S. (1960): Wool Fabrics as Garment Construction Materials. Journal of Textile Institute, 51 (1960) 2, pp. T1457-T1493.
9. Bona, M. (1994): Textile Quality, Physical Methods of Product and Process Control. Textilia, Instituto per la Tradizione e la Techonologia Tessile, Biella, 1994.
10. Chu, C. C., Cumminngs, L.C., Teixeira, N. A. (1950): Mechanics of Elastic Performance of Textile Materials. Part V: A Studiy of the Factors Affecting the Drape of Fabrics - The Development of a Drape Meter. Textile Research Journal, 20 (1950) 8, pp. 539-548.
11. Cusick, G. E. (1965): The Dependence of Fabric Drape on Bending and Shear Stiffness. Journal of Textile Institute, 56 (1965) 11, pp. 596-606.
12. Chu, C. C., Cumminngs, L.C., Teixeira, N. A. (1950): Mechanics of Elastic Performance of Textile Materials. Part V: A Study of the Factors Affecting the Drape of Fabrics - The Development of a Drape Meter. Textile Research Journal, 20 (1950) 8, pp. 539-548.
13. Jeong, Y.J., Phillips, D. G. (1998): A Study of Fabric Drape Behaviour with Image Analysis Part II. The Effects of Fabric Structure and Mechanical Properties on Fabric Drape. Journal of Textile Institute, 89 (1998) 1 pp. 70-79.
14. Potter, K. (1997): An Introduction to Composite Products, Design, Development and Manufacture. Chapman & Hall, London, 1997.
15. Hull, D. (1981): An Introduction to Composite Materials. Cambridge University Press, Cambridge, 1981.
16. Hu, J., Chen, S., Teng, J.G: Numerical Drape Behaviour of Circular Fabric Sheets Over Circular Pedestal. Textile Research Journal, 70 (2000) 7, pp. 593-603.
17. Yu, D.K:C:, Kennon, R. Potluri, P. Computer-Based 3D Modelling of the Drape of Woven Fabrics. Dmm'99, Strojniški vestnik, pp. 677-684.
18. ABAQUS, (2000a), User Manuel. Volume I, II, III, Version 6.2, Hibbitt, Karlsson.

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