ISSN 1392–1320 MATERIALS SCIENCE (MEDŽIAGOTYRA). Vol. 17, No. 2. 2011

The Influence of Textile Materials Mechanical Properties upon Virtual Garment Fit

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Received 10 November 2010; accepted 24 April 2011

3D virtual representation of garment provides high potential for design, product development and marketing processes, especially in mass customization strategies implementation. Clothing industry rapidly turns to virtual simulation which not only presents realistic 3D view of garment but also simulates mechanical behaviour of materials. 3D CAD systems can be used to define strain distribution in virtual garment which describes garment fit without actually producing the garment. Strain and distance ease between body and garment depends not only upon body measurements and garment construction, but also on mechanical and structural properties of selected material. The aim of this research was to investigate virtual garment fit using "Modaris 3D Fit" (Lectra) software subjected to fabrics mechanical (tensile, bending, shear) and structural (composition, thickness, area density) properties investigating strain distribution in garment and distance ease between garment and human body. It was defined that for diagonal cut garments the highest influence upon garment fit has fabric tensile properties in weft direction. The highest influence is obtained at high distance ease and small strain values zones and at negative distance ease and high strain values zones. Therefore, presented method could be used for tight-fitted garments also for garments with draperies on purpose to investigate garment fit upon fabrics used.

Keywords: distance ease, KES-F, strain distribution, mechanical properties of textile materials, virtual garment fit.

1. INTRODUCTION

Recently with the advancing of the 3D computer technology and the demand of made-to-measure garment, it becomes a major trend to extend the 2D garment CAD into 3D in the garment industry and computer technology. 3D garment modelling now is one of the most interesting topics in the textile engineering, computer graphics and 3D garment CAD [1, 2]. 3D virtual representation of garment provides high potential for design, product development and marketing processes.

Advancements in 3D software usable for garment fit evaluation are being made [3] but technology is based on the ideal model, and the space relation between virtual body and virtual garment is not very clear [1, 4]. So, 3D garment design remains an active area of research and this survey is not meant to be complete [2].

Fitness of clothing with body is an important factor to design comfortable and functional clothing [5]. Now, most apparel CAD systems (Gerber Technology, Lectra, Optitex) have 3D virtual clothing simulation softwares for garment fit evaluation. While the garment is constructed from 2D patterns, the quality of fit is evaluated on 3D human models [2]. For this purpose distance ease, wearing silhouette and distribution of strain in virtual garment is analysed without actually producing the garment [6].

The distance ease between body and garment is a main concern of the apparel fit [4]. J. Xu and W. Zhang [1] keep distance ease of garment as the shortest distance from the body surface to the inner surface of clothes on the horizontal cross section curve. In other research [7], three types of ease allowance were distinguished: standard ease, dynamic ease and fabric ease.

Garment fit depends not only on body measurements and garment construction, but also on mechanical and structural properties of selected fabric [4, 5, 8]. Taya Y. et al. [5] found that clothing waveform depends on mechanical properties of material. She stated that material type changing has higher influence upon clothing waveform than size changing. Xu J. et al. [4] also maintained that there are relation between distance eases and material mechanical properties.

Garment pressure is closely related to the space allowance between the body and the garment during body movement [9]. When a garment girth measurement is smaller than human body, pressure is generated. Therefore, garment fit and pressure comfort plays an important role in clothing comfort and function of a garment, especially for tight-fit sportswear [10, 11], also for women's foundation and burned patients' recovery shell [12].

Garment pressure and garment fit are affected by body shape, mechanical properties of the fabric and the style of the garment [10, 9]. You F. et al. [11] defined that pressure wearing comfort is dependent upon extensibility of fabrics and fitness of garments. Krzywinski S. et al. [13] also affirmed that fabric extensibility is significant mechanical parameter for close-fitting garments. Garment construction, fabrics used, garment fit and positioning on body plays a significant role in the amount of predictive pressure generated by the compression garments [14].

The aim of this research was to investigate virtual garment fit using "Modaris 3D Fit" (Lectra) software subjected to fabrics mechanical (tensile, bending, shear) and structural (composition, thickness, area density) properties investigating strain distribution in garment and distance ease between garment and human body.

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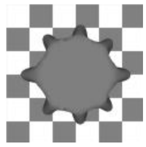
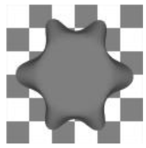
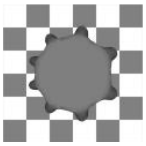
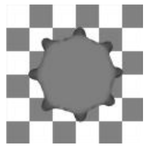
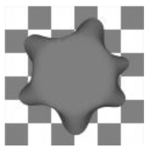
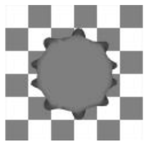
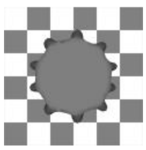
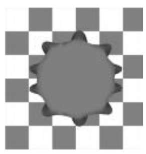
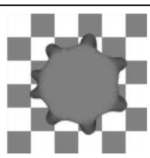
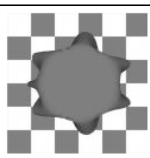
MATERIALS AND METHODS

Tests were performed with ten cotton or cotton blended fabrics which differed in structure (Table 1) and mechanical characteristics (Table 2).

Table 1. Structure characteristics of tested fabrics

Code	Yarn composi-tion, %	Thick-ness, mm	Weave	Area density, g/m^2	View of draped fabric sample
cotton11	100 Cotton	0.58	Plain	155	
cotton30	100 Cotton	0.66	Plain	304	
cotton80	100 Cotton	0.69	Plain	118	
stretch cotton17	99 Cotton, 1 EL	0.62	Plain	145	
stretch cotton20	98 Cotton, 2 EL	0.71	Twill	258	
stretch cotton22	91 Cotton, 8 PA, 1 EL	0.46	Plain	131	
stretch cotton23	94 Cotton, 5 PA, 1 Lycra	0.60	Plain	192	
stretch cotton28	45 Cotton, 50 PES, 5 EL	0.44	Plain	119	
stretch cotton73	45 PES, 53 Cotton, 2 Lycra	0.70	Twill	265	
stretch cotton86	82 PA, 16 Cotton, 2 EL	0.42	Twill	214	

PA – polyamide, PES – polyester, EL – elastane.

In order to avoid size difference, it is better to use the standard mannequin in the study of the garment distance ease [1]. In our research the tests were performed with 36 size women mannequin (Fig. 1) dressed with close-fitted dress (Fig. 2).

Because the distribution of distance ease is not even, ease allowance is necessary to control on breast, waist and hip areas [1, 15]. In these body areas nearly half of the respondents reported fit problems [16]. Therefore, for tested virtual dress different fabrics were adjusted and distance eases also strains in three main zones – bust, waist and hips were measured. It should be mentioned that all three zones coincide with diagonal cut patterns (Fig. 2). Distance ease between garment and virtual body could be illustrated by cross-section at waist zone (Fig. 3).

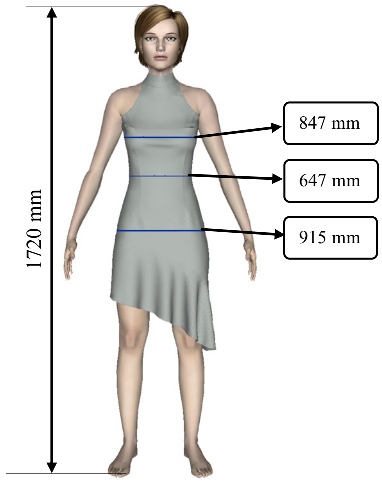


Fig. 1. Virtual mannequin with marked bust, waist and hip zones

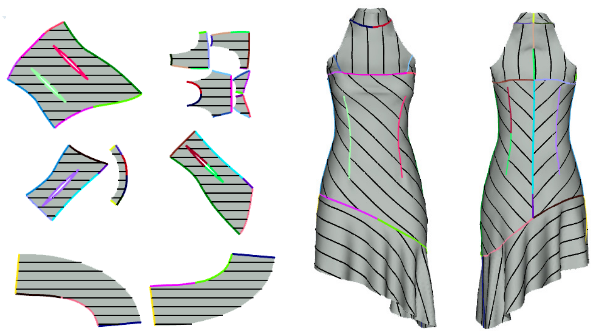


Fig. 2. Direction of warp thread in patterns and virtual dress with marked seam lines

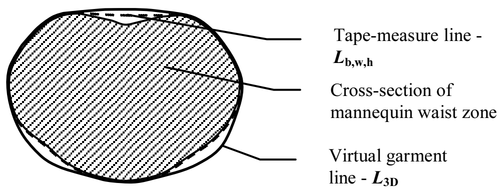


Fig. 3. Cross-section of virtual mannequin waist zone with tape-measure and virtual garment lines

Mechanical properties of tested fabrics defined using KES-F system were inputted into the virtual garment simulation software "Modaris 3D Fit" (Lectra). This software was used in our research to investigate the influence of textile materials mechanical properties upon close-fitted virtual garment fit.

Table 2. Mechanical characteristics of tested fabrics

Code	Bending resistance *B* (10^{-6} Nm)		Tensile resistance						Shearing resistance				Friction *MIU*	
			EMT (%)		*LT*		*WT* (N/m)		*G* ($Nm^{-1}/°$)		*T* (Nm^{-1})			
	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft
Cotton11	12.26	9.56	4.10	3.83	0.790	0.773	7.95	7.26	2.94	2.88	15	15	0.1815	0.1838
Cotton30	45.37	94.42	4.31	1.71	0.613	0.632	6.48	2.65	4.17	3.56	49	49	0.1360	0.1507
Cotton80	6.49	6.45	7.13	22.94	0.622	0.469	10.87	26.39	0.45	0.32	10	10	0.2142	0.2170
Stretch cotton17	7.60	5.15	8.38	12.10	0.680	0.633	13.98	18.79	1.28	1.25	15	15	0.1802	0.1730
Stretch cotton20	82.16	41.69	2.38	22.51	0.790	0.685	4.61	37.82	5.83	3.01	49	49	0.1582	0.1735
Stretch cotton22	7.97	2.82	4.58	33.65	0.677	0.532	7.60	43.90	1.28	1.15	10	10	0.1512	0.1635
Stretch cotton23	9.93	8.71	4.73	27.23	0.647	0.553	7.51	36.94	1.84	1.35	15	15	0.1755	0.1807
Stretch cotton28	10.18	3.43	4.79	16.95	0.647	0.538	7.60	22.37	1.59	1.25	15	15	0.1428	0.1518
Stretch cotton73	26.36	17.47	6.29	24.31	0.759	0.677	11.72	40.37	2.58	2.51	10	10	0.1628	0.1245
Stretch cotton86	47.48	4.42	3.45	23.45	0.623	0.506	5.27	29.09	1.10	0.66	15	15	0.1245	0.2638

For the investigation of virtual garment fit distance ease values in patterns and virtual garment, also strain in three zones – bust, waist and hips were measured. For this reason measurable and calculable parameters were used. The measurable parameters were as following:

1. $L_{b,w,h}$ – length (mm) of virtual mannequin in correspondent zone (bust, waist, hip) taken by virtual tape-measure – dotted line in Figure 3.

2. L_{3D} – length (mm) of virtual garment cross-section in correspondent zone – continuous line in Figure 3.

3. L_{2D} – length (mm) of 2D patterns measured in correspondent zone.

Calculable parameters were as following:

1. $ES_{2Db,w,h}$ – distance ease (mm) of 2D patterns in correspondent zone:

$$ES_{2Db,w,h} = L_{2D} - L_{b,w,h} \quad (1)$$

2. $ES_{b,w,h}$ – distance ease (mm) of 3D garment in correspondent zone – difference between continuous and dotted lines (Fig. 3):

$$ES_{b,w,h} = L_{3D} - L_{b,w,h} \quad (2)$$

3. $EL_{b,w,h}$ – strain (%) of 3D virtual garment in correspondent zone (bust, waist, hip):

$$EL_{b,w,h} = (EL/L_{2D}) \cdot 100 \quad (3)$$

here EL – elongation (mm) – difference between ease, measured in 2D patterns and 3D garment and is adequate to fabric elongation (mm) in tested zone:

$$EL = ES_{b,w,h} - ES_{2Db,w,h} \quad (4)$$

In our research not only distance ease and strain values in different zones were estimated but also distribution of them in virtual garment was analyzed. In 3D system, the garment is divided into hundreds of small triangular finite elements. Each element is viewed as an elastic material [6]. Right size of triangle mesh should be chosen because the accuracy of computation depends on it. Material behaviour is attributed to the mesh to simulate the development depending on the material type [8].

For this reason virtual garment was divided into triangle mesh with different sizes (10, 15, 20, 25 and 30 mm) and simulation time (min), also coefficient of variation v (%) was defined. This analysis was done with the same fabric (stretch cotton20) three times for each mesh size at the same computer. The results showed (Fig. 4) that least simulation time was got with the highest mesh size (30 mm) but the smallest variation v of results was obtained with the mesh size of 20 mm.

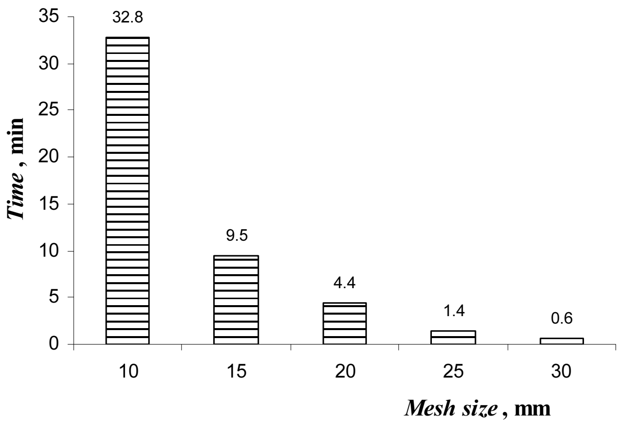


Fig. 4. Dependency of simulation time upon virtual garment mesh size

The coefficient of variation v was defined also for distance ease and strain results in bust, waist and hip zones and average values were calculated (Table 3).

Table 3. The coefficient of variation v dependent on mesh size

Mesh size, mm		10	15	20	25	30
The coefficient of variation v, %	time	4.65	5.22	1.52	2.19	3.70
	ease average	1.20	1.04	0.70	0.99	1.35
	strain average	3.06	2.74	2.20	2.47	3.09

The results have confirmed that the smallest variation was obtained with mesh size of 20 mm. Thus, for the investigation of textile materials mechanical properties influence upon garment fit the mesh size of 20 mm was chosen.

For the possibility to compare distance ease and strain distribution in virtual garment with different fabrics, constant ease and strain values were chosen: for ease 50 mm (Fig. 5) and for strain 6 % (Fig. 6). Distribution was analysed in virtual garment and in separate patterns.

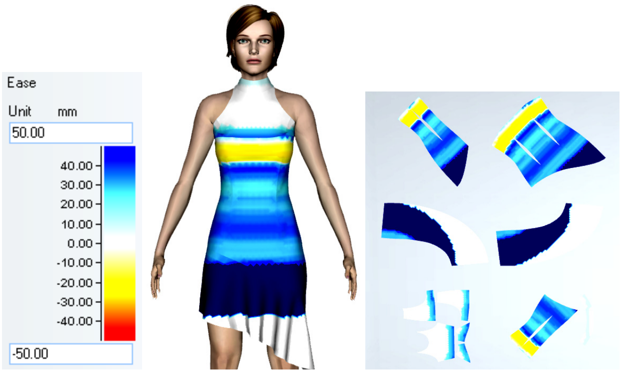


Fig. 5. Distance eases ES_{2D} distribution in virtual dress and patterns

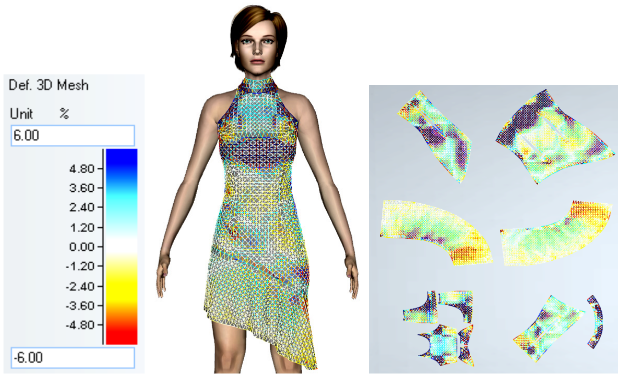


Fig. 6. Strain *EL* distribution in virtual dress and patterns

For the comparison of strain values in patterns, strain measure point was chosen at maximum strain cross-section – bust zone, in the middle of the front pattern (Fig. 7).

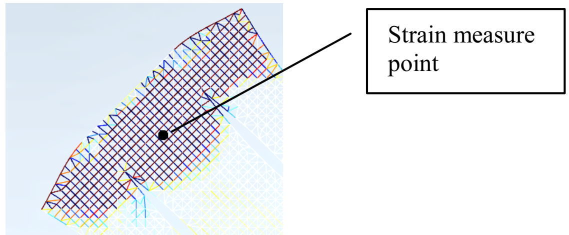


Fig. 7. Strain measure point in front pattern at bust level

Each measurement of distance ease and strain values in bust, waist and hip zones was taken three times and coefficient of variation *v* was calculated. The correlation analysis was applied to find which mechanical parameters (Table 2) influence distance ease and strain values of tested virtual garment at bust, waist and hip zones.

RESULTS AND DISCUSSION

Distance ease and strain results at close-fitted virtual garment tested zones – bust, waist and hip confirmed that fabric influence garment fit (Table 4). The coefficient of variation *v* did not exceed 6 %.

The highest distance ease values were obtained at hip zone, when the highest elongation values were defined at bust zone (Table 4). Also it was estimated that distance ease ES_{2D} values at bust zone were negative what means that pressure would be generated [10]. At waist and hip zones values were positive, so pressure would not be generated.

The highest dependency of distance ease ES_{2D} upon used fabric was defined at hip zone because values spread the most (46 %), when the smallest dependency was defined at waist zone (10 %).

Next distribution of distance ease ES_{2D} and elongation *EL* in virtual garment with different tested fabrics was analyzed (Figs. 8 – 10).

Table 4. The values of distance ease $ES_{2Db,w,h}$, $ES_{b,w,h}$ and strain $EL_{b,w,h}$ for tested fabrics

Code	Bust						Waist						Hips					
	ES_{2Db}		ES_b		EL_b		ES_{2Dw}		ES_w		EL_w		ES_{2Dh}		ES_h		EL_h	
	mm	v, %	mm	v, %	%	v, %	mm	v, %	mm	v, %	%	v, %	mm	v, %	mm	v, %	%	v, %
Cotton11	–23.08	1.48	21.83	0.40	5.45	0.84	28.66	1.77	36.94	0.82	1.22	4.93	47.51	0.97	48.13	1.17	0.06	4.23
Cotton30	–21.01	1.11	26.59	2.57	5.33	2.52	27.87	0.73	38.65	3.05	1.50	3.01	45.14	1.93	47.94	1.06	0.21	4.76
Cotton80	–16.55	0.77	26.50	3.64	5.20	1.49	27.12	1.91	33.07	2.38	0.89	4.89	32.50	0.86	34.74	0.50	0.22	2.58
Stretch cotton17	–21.58	3.60	21.93	1.51	5.27	1.84	27.52	2.22	35.3	0.47	1.22	1.26	41.86	0.85	42.74	0.77	0.09	0.00
Stretch cotton20	–20.94	1.27	20.68	3.09	5.04	2.12	27.83	1.91	34.15	0.06	0.86	0.83	40.14	0.32	41.43	0.47	0.13	4.56
Stretch cotton22	–18.07	0.71	21.67	0.51	4.79	0.12	27.13	1.68	33.25	1.27	0.91	2.55	35.52	2.84	37.49	3.09	0.14	4.22
Stretch cotton23	–17.73	2.04	22.48	1.05	4.84	0.85	26.98	1.23	32.89	1.71	0.89	1.72	34.75	2.22	36.72	2.23	0.21	4.76
Stretch cotton28	–21.79	1.59	20.49	2.13	5.17	1.10	27.58	4.74	33.77	3.1	0.91	4.42	41.41	1.76	42.32	1.22	0.10	5.59
Stretch cotton73	–18.03	4.19	22.34	3.06	4.72	4.58	26.58	0.52	32.78	1.03	0.92	3.14	37.41	3.42	38.93	2.86	0.17	4.45
Stretch cotton86	–16.46	2.53	25.68	0.78	5.06	0.30	26.04	0.09	32.36	0.33	0.94	1.06	32.57	0.99	35.57	0.72	0.32	6.44

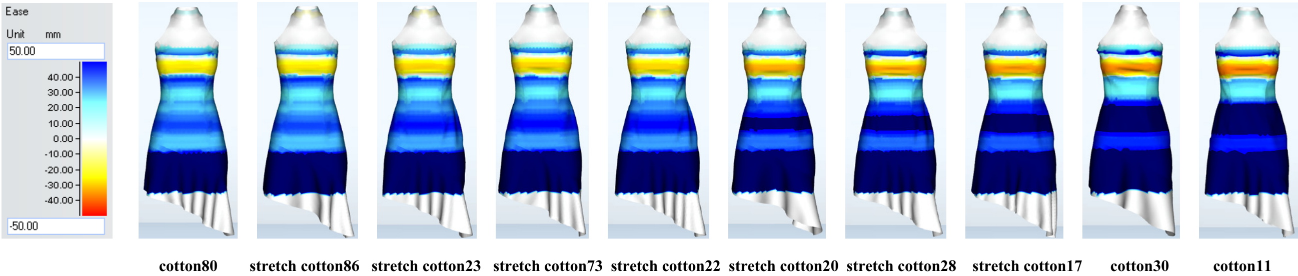


Fig. 8. Distribution of distance ease ES_{2D} in virtual dress with tested fabrics (sorted by ES_{2Dh} value at hip zone from the lowest to the highest (Table 4))

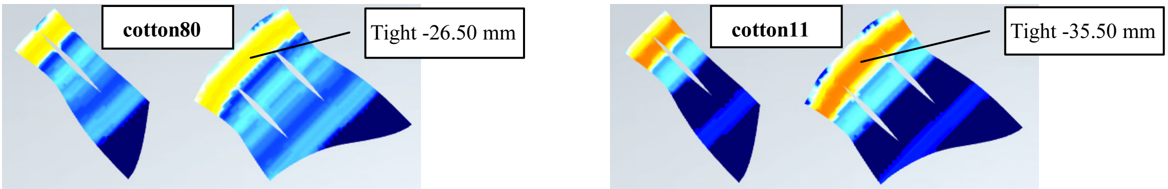


Fig. 9. Comparison of distance ease ES_{2D} distribution in virtual dress front and back patterns with cotton80 and cotton11 fabrics

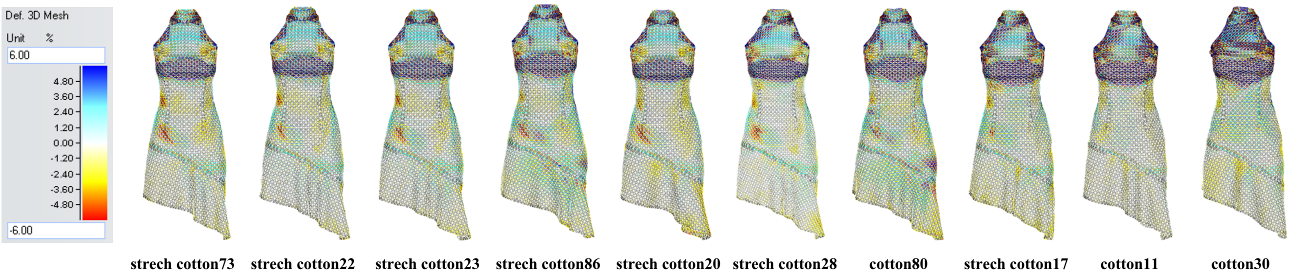


Fig. 10. Distribution of strain EL in virtual dress with tested fabrics (sorted by EL at strain measure point (Fig. 7, Table 5) from the lowest to the highest)

For visual comparison of distance ease distribution using different tested fabrics, virtual garments were sorted by ES_{2Dh} values at hip zone (Fig. 8). The lowest distance ease values were obtained with fabric cotton80 and the highest with fabric cotton11. The smallest distance ease could be explained by the smallest shear rigidity G value of fabric cotton80 (Table 2).

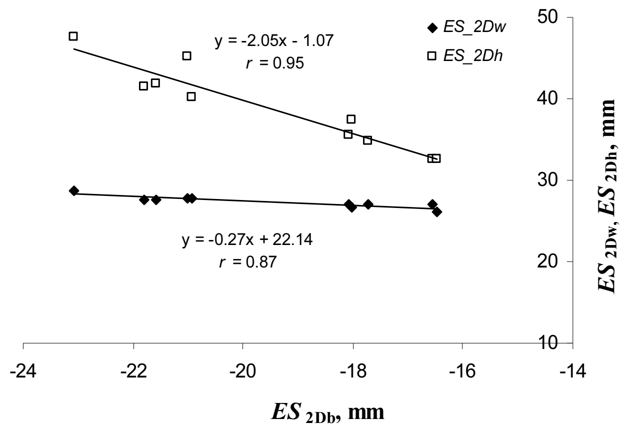


Fig. 11. Relationship between distance ease ES_{2D} at bust zone and distance ease at waist, also hip zones

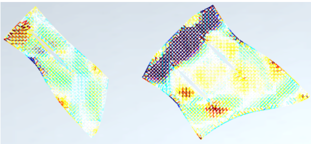
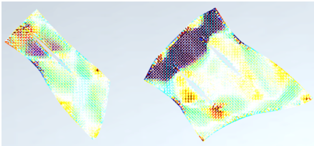
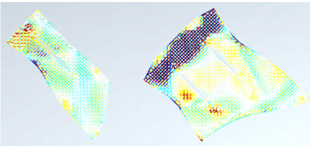
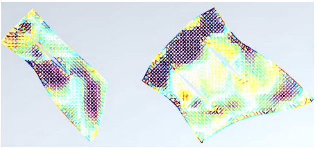
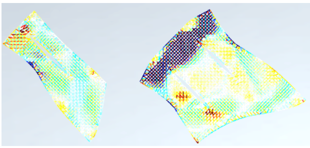
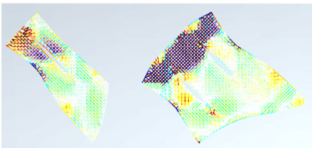
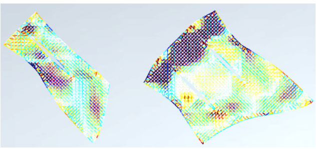
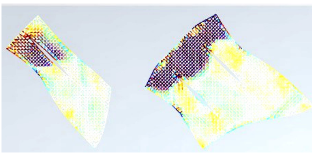
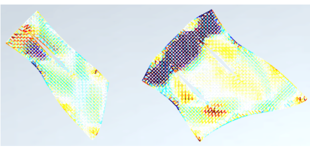
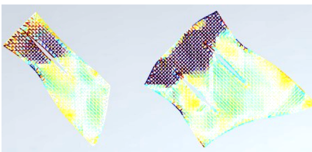
Comparison between distance ease values of these two marginal fabrics (Fig. 9) showed that difference of distance ease at the same measure point (Fig. 7) is 34 %. Also we can see that distance ease ES_{2D} with fabric cotton11 at hip zone is the highest when at bust zone is the smallest, e. g. the most tight, and vice versa for fabric cotton80 (Table 4). This means that distance ease at bust and hip zones is inversely proportional, e. g. has negative relationship (Fig. 11).

The same relationship at waist zone showed slight negative character. Distance ease at bust and hip zones could show such strong negative relationship because of fabric elongation in virtual garment – at hip zone distance ease values are the highest and strain values are the smallest (Table 4). While at bust zone distance ease values are negative with pressure generated, so the highest strain of fabric is established.

Distribution of strain EL in virtual dress (Fig. 10) with tested fabrics showed that the highest influence was obtained in bust zone and strain differed here even 64 % (at the same measure point (Table 5)).

Further distance ease in 3D virtual garment $ES_{b,w,h}$ using different fabrics was analyzed. It was observed that distance ease in 2D patterns (ES_{2D}) and in 3D garment (ES) has positive relationship (Fig. 12). The highest coefficient of correlation r was observed at hip zone, where distance eases were the highest. And the weakest correlation was observed at bust zone, where pressure would be generated. In this zone one fabric (cotton 30) dropped from relation and after elimination of it coefficient of correlation becomes $r = 0.74$. It could be stated that from distance ease in 2D patterns ES_{2D} distance ease in 3D virtual garment could be predicted only if distance ease has positive values.

Table 5. Strain distribution in patterns with measured strain value at bust point

1. stretch cotton73 (9.4 %) 	6. stretch cotton28 (11.4 %) 
2. stretch cotton22 (9.5 %) 	7. cotton80 (strain 11.6 %) 
3. stretch cotton23 (9.7 %) 	8. stretch cotton17 (12.7 %) 
4. stretch cotton86 (10.1 %) 	9. cotton11 (13.8 %) 
5. stretch cotton20 (10.8%) 	10. cotton30 (15.4 %) 

Next correlation analysis was done to define mechanical parameters which influenced garment fit, e. g. virtual garment distance ease and strain values. For this reason correlation coefficients were calculated (Table 6).Correlation analysis has shown that the highest influence for distance ease and strain at bust, waist and hip zones had fabric strain *EMT* and tensile energy *WT* in weft direction. Influence of shear rigidity *G* was weaker and more impact was defined for distance ease than for strain.

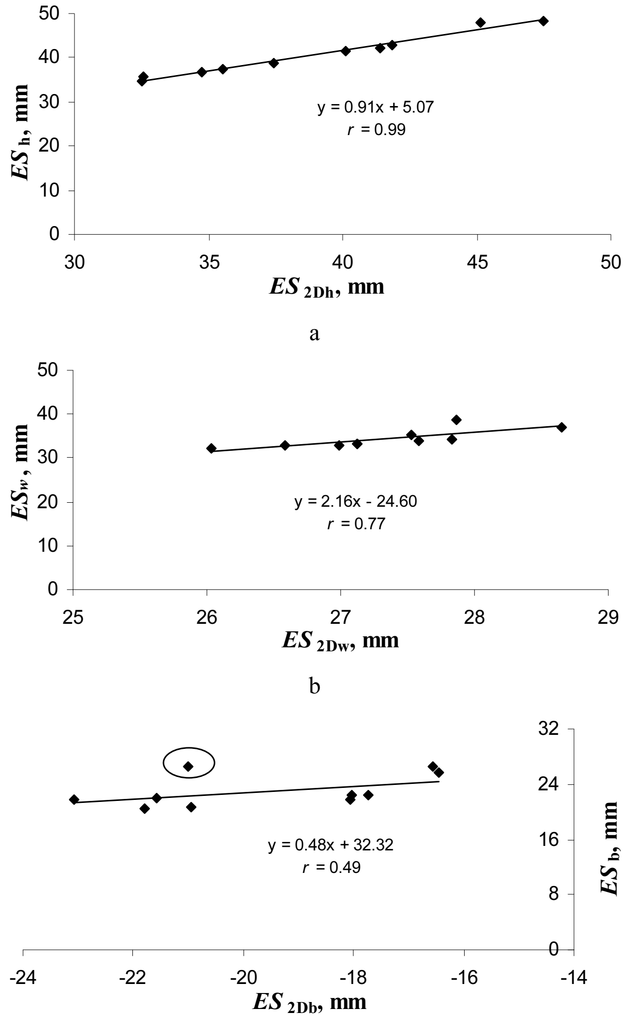
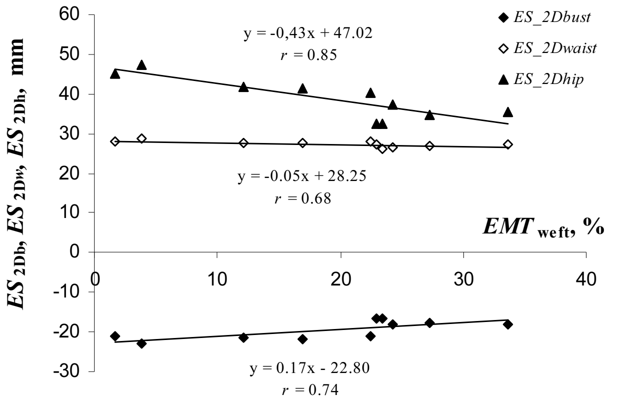


Fig.12. Relationship between distance ease in 2D patterns $ES_{2Db,w,h}$ and in 3D virtual garment $ES_{b,w,h}$

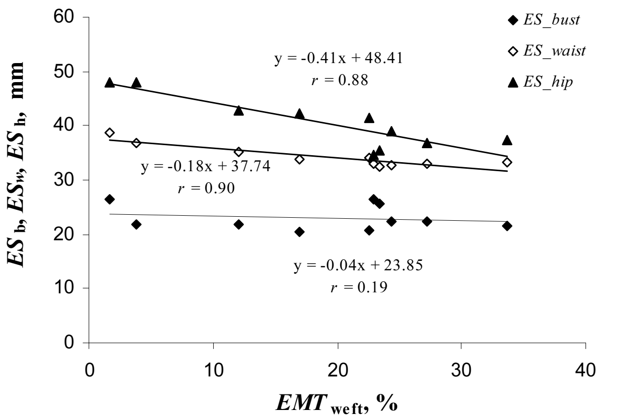
Table 6. The correlation coefficients *r* between mechanical parameters of tested fabrics and measured distance ease $ES_{2Db,w,h}$ and $ES_{b,w,h}$ and strain $EL_{b,w,h}$ (correlations ≥0.60 are picked out in *italic*)

Mechanical parameters		Direction	Bust			Waist			Hip		
			ES_{2Db}, mm	ES_b, mm	EL_b, %	ES_{2Dw}, mm	ES_w, mm	EL_w, %	ES_{2Dh}, mm	ES_h, mm	EL_h, %
Bending	*B*	Warp	–0.06	0.07	–0.02	–0.01	0.11	–0.01	0.08	0.13	0.27
		Weft	–0.28	0.38	0.27	0.33	*0.70*	*0.65*	0.45	0.55	0.13
Tensile	*EMT*	Warp	0.10	0.13	0.06	–0.13	–0.07	0.12	–0.11	–0.15	–0.16
		Weft	*0.74*	–0.19	*–0.87*	*–0.68*	*–0.90*	*–0.87*	*–0.85*	*–0.88*	0.32
	LT	Warp	–0.44	*–0.64*	–0.06	0.43	0.09	–0.12	0.41	0.34	*–0.61*
		Weft	*–0.71*	–0.40	0.28	*0.64*	0.58	0.44	*0.78*	*0.75*	*–0.60*
	WT	Warp	0.00	–0.03	0.02	–0.06	–0.05	0.11	0.00	–0.07	–0.31
		Weft	*0.61*	–0.35	*–0.92*	*–0.61*	*–0.86*	*–0.86*	*–0.73*	*–0.77*	0.20
Shear	*G*	Warp	–0.49	–0.22	0.12	0.50	0.48	0.26	0.54	0.56	–0.23
		Weft	*–0.60*	–0.15	0.22	*0.59*	*0.70*	0.55	*0.75*	*0.78*	–0.34
	T	Warp, Weft	–0.39	0.11	0.28	0.41	0.57	0.42	0.44	0.50	0.02

Relationship between distance ease ($ES_{2Db,w,h}$ and $ES_{b,w,h}$), strain ($EL_{b,w,h}$) and fabric tensile strain EMT_{weft} (also tensile energy WT_{weft}) in weft direction could be described by linear equation (Fig. 13).



a



b

Fig. 13. Relationship between fabric tensile strain EMT_{weft} and distance ease ES_{2D} (a) and ES (b)

This relation shows that by increasing of fabric tensile strain (and tensile energy) in weft direction, distance ease and strain in close-fitted garment declines slightly. This could be explained by the fact that the higher the fabric strain, the better it fits 3D form, so the smaller distance ease is obtained. The decline at hip zone is the sharpest because of the highest distance ease values at this zone (Table 4). Also we can see that relationship where negative distance ease values (bust zone) are defined (Fig. 13, a) is positive, e.g. by increasing of fabric tensile strain EMT_{weft}, distance ease ES_{2D} increases slightly too, e. g. declines negative value of distance ease and therefore declines pressure generated.

Relationship between fabric tensile strain EMT_{weft} and virtual garment strain EL at bust, waist and hip zones showed (Fig. 14) that by increasing of fabric tensile strain garment strain decreased slightly. This relation was not defined at hip zone where garment strain was the smallest. While at the highest strain zone (bust) the largest slope angle was obtained. This means that influence of fabric tensile strain upon virtual garment strain is the most important in garment compression areas.

Our finding that tensile strain in weft direction is the most important mechanical parameter influencing garment fit corresponds to Lai S.S. investigations [17] who stated that fabric weft elongation is important factor affecting garment comfort.

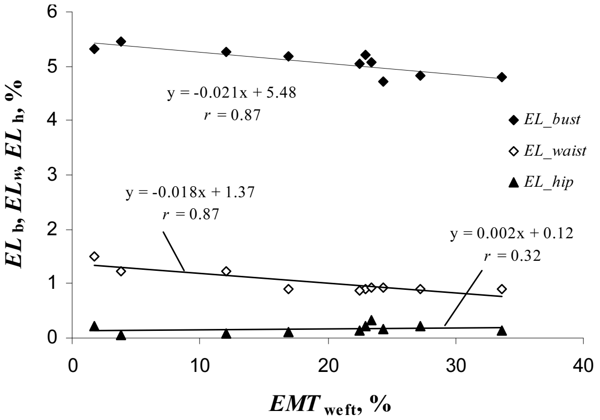


Fig. 14. Relationship between fabric tensile strain EMT_{weft} and virtual garment strain EL

The coefficient of correlation between shear rigidity G_{weft} and distance ease ES_{2D} (Table 6, Fig. 15) showed positive relation in waist and hip zones and negative in bust zone. Positive relation showed that by increasing of fabric shear rigidity distance ease increases too.

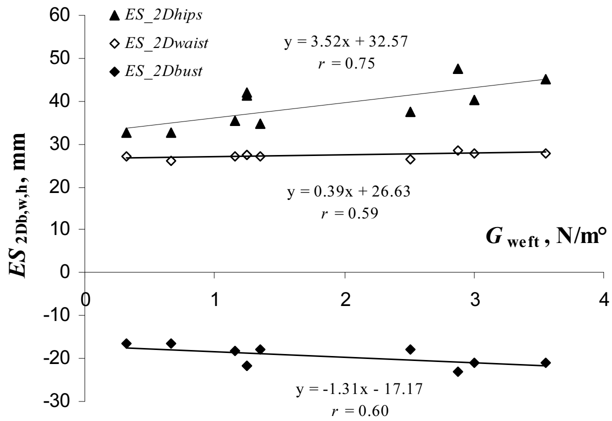


Fig. 15. Relationship between fabric shear rigidity G_{weft} and distance ease ES_{2D}

This phenomenon was analyzed and it was found that because of diagonal direction of patterns a wave was formed at hip zone in one side (Fig. 16). The biggest wave was formed for the highest shear rigidity fabrics and this give a reason why distance ease values increased. In waist zone wave didn't form, so relationship was almost horizontal (Fig. 15). In bust zone, where distance ease values were negative, growing of shear rigidity G_{weft} values increased negative values of ES_{2Db} slightly, so pressure generated would grow, but relation was not strong.

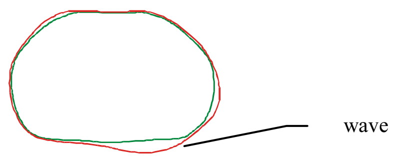


Fig. 16. Wave formed in virtual garment at hip cross-section zone

Obtained results and findings correspond to Xu J. study [4] who stated that the main factors which affected distance eases were tensile deformation, bending, shear and overhanging factor of material. In our study bending rigidity *B* was not estimated as parameter influencing garment fit. It could be explained because of diagonal direction of patterns. In this case tensile strain and shear parameters play the main role in garment fit.

Existing garment CAD systems use 2D patterns with predefined standard values of ease allowances for any body shape and any type of fabric. Differences in fabric properties that can produce differences in garment fit may require the implementation of additional variables [18]. Krzywinski S. et al. [13] stated that for implementation of material parameters into the pattern construction elongation factors should be calculated. In our study it was proved that fabric mechanical properties influence garment fit and according this garment patterns can be corrected, also proper fabrics could be chosen to achieve the best garment fit.

CONCLUSIONS

In our research virtual garment fit measuring distance ease and strain was investigated. It was proved that virtual garment would fit different on the human body depending on whether it is made. It was defined that for diagonal cut garments the highest influence ($r = 0.61 – 0.85$) upon distance ease had fabric tensile properties in weft direction. Shear rigidity in weft direction influences garment balance especially in hip zone but influence was weaker ($r = 0.59 – 0.75$). This result should be tested for straight cut garments additionally and is intended in our further research.

The highest influence (46 % – 64 %) of different fabric used upon virtual garment fit was obtained at high distance ease and small strain values zone (hip zone) and at negative distance ease and high strain values zone (bust zone). So, presented method could be used not only for garments with draperies but also for close fitted garments fit evaluation where high standards of fit should be hold.

Paper also provides important information for the researchers to identify future research directions in 3D garment fit investigations.

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Presented at the National Conference "Materials Engineering'2010"
(*Kaunas, Lithuania, November 19, 2010*)