

Investigation of Fused Textile Systems Resilience Properties

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Abstract: The aim of the research was to investigate the effect of interlinings orientation upon fused textile systems resilience and to define the relation between fused textile systems pendulum impact behaviour (biaxial deformation) and mechanical properties determined by KES-F system (uniaxial deformation).

Outer fabric and two interlinings with polymer adhesive layer: non-woven with longitudinal threads P1 and warp knitted TR1 were investigated. Fused textile systems were formed by changing the orientation of interlinings at: 0° (system PAR), 90° (system PER) and 45° (system B) degrees in respect to outer fabric warp direction. For the investigations of fused textile systems resilience properties computerized pendulum impact device was applied. Tensile properties were determined using KES-F system.

The investigations of the effect of interlinings orientation upon fused textile systems resilience have shown that this property is the highest for B systems. Resilience of fused textile PAR systems is the lowest because tensile strength of interlinings in longitudinal direction defined by KES-F system is the highest. Meantime for fused PER systems it is no difference which interlining can be chosen for fusing because resilience properties of both systems are almost similar.

The investigations of bilayered fused textile systems have revealed that the parameters of biaxial behaviour obtained in impact loading are related with the anisotropy of tensile strain EMT and tensile resilience RT determined by uniaxial KES-F testing, i.e. the increase of rebound angle α_1 and decrease of impact angle β_1 are closely related with the decrease of EMT and RT anisotropy.

Keywords: resilience, interlining, polymer adhesive layer, fused textile system, layer orientation, pendulum impact, KES-F

I INTRODUCTION

Textile materials are not homogenous and are well known for their property-direction dependence or property anisotropy [1]. Furthermore the behaviour of textile materials is not linear, their experimental anisotropy curves are not smooth [2, 3]. Classical uniaxial tensile tests providing stress/strain dependencies are extensively used methods for textile properties evaluation. Besides, there is significant number of specific test methods based on the principle of biaxial (plain, membrane and punch) deformation, the advantage of which is better simulation of fabric behaviour in real service conditions [4].

Resilience of textile materials is one of the main exploitation parameters describing the quality of garments and their stability during wear [5, 6]. Earlier investigations of textile materials pendulum impact deformation have shown that close dependency exists between their strain level and absorbed impact energy [7, 8]. Moreover linear relationship exists between resilience of these materials and absorbed pendulum impact energy [9]. Earlier investigations have also

shown that resilience of textile materials can be improved by creating bilayered systems, i.e. by fusing fabrics with interlining materials orientated in proper direction [10].

Thus, the aim of this research was to investigate the effect of interlinings orientation upon fused textile systems resilience and to define the relation between fused textile systems pendulum impact behaviour (biaxial deformation) and mechanical properties determined by KES-F system (uniaxial deformation).

II EXPERIMENTAL

In this research outer fabric M5 (Table 1) and two interlinings with polymer adhesive layer: non-woven with longitudinal threads P1 and warp knitted TR1 were investigated (Table 2 and Fig. 1).

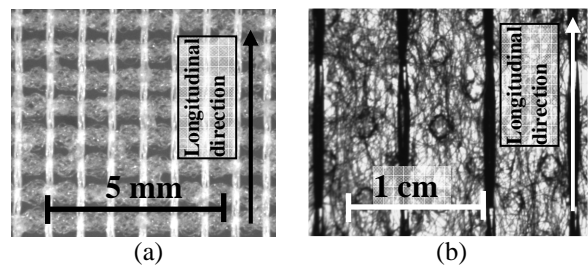


Fig. 1. View of interlinings: warp knitted interlining TR1 (a); non-woven interlining P1 (b)

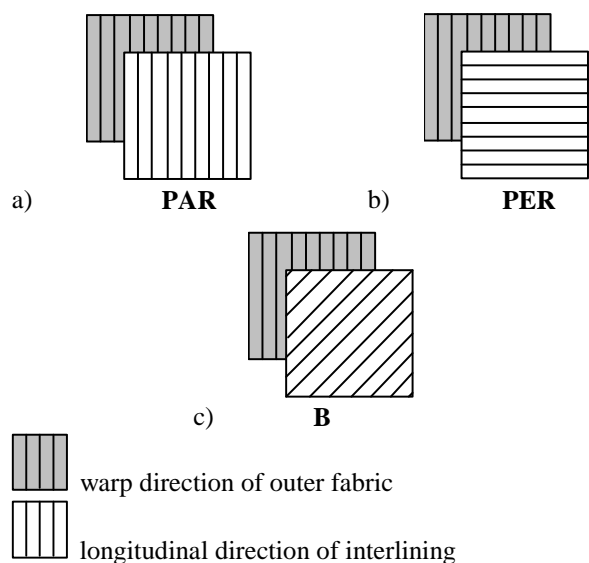


Fig. 2. Types of fused textile systems: PAR - the directions of outer fabric and interlining are parallel (a); PER - interlining is orientated perpendicularly (at 90°) to outer fabrics warp direction (b); B - interlining is bias orientated (at 45°) in respect to outer fabrics warp direction (c)

TABLE 1
CHARACTERISTICS OF OUTER FABRIC

Material	Composition	Area density W , g/m^2	Thickness T_m , mm	Density*, 1/cm		Linear density, tex	
				Warp	Weft	Warp	Weft
M5	50 % wool, 50 % CA	222	1.55	16.2	12.0	63	70

Notes: CA – acetate; *- number of threads per cm

TABLE 2
CHARACTERISTICS OF FUSIBLE INTERLININGS AND THEIR ADHESIVE LAYER

Material	Composition		Area density W , g/m^2	Thick-ness T_m , mm	Density*, 1/cm		Adhesive mesh, dots/ cm^2	Fusing conditions		
	Base	Adhe-sive			Coarse	Wale		τ , s	t , °C	P , MPa
P1	100% PES	PA	38	0.56	2.4	-	52	15	140	0.04
TR1	100% PES	PA	35	0.40	14	13	118	15	140	0.04

Notes: *- number of threads per cm, τ - duration, t – temperature, P – pressure, PES - polyester, PA - polyamide

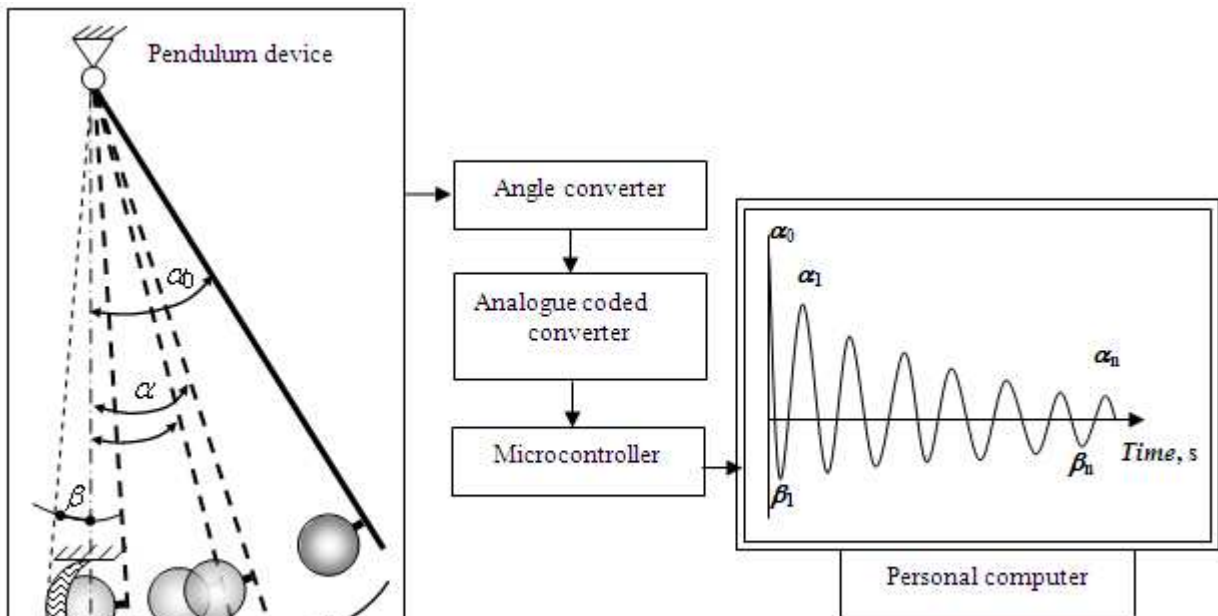


Fig. 3. Pendulum impact device and registration of its vibration process (α_n – amplitudes of the rebound angles, β_n – amplitudes of impact angles)

Fused textile systems were formed by changing the orientation of interlinings at: 0° (system PAR), 90° (system PER) and 45° (system B) degrees in respect to outer fabric warp direction (Fig. 2).

For the investigations of fused textile systems resilience properties computerized pendulum impact device was applied (Fig. 3). Pendulum rebound α_n and impact β_n (n are the numbers of pendulum swings) angles were determined. During testing the pendulum is raised from the balance position and is fixed at the initial angle α_0 .

When the pendulum is released the bob strikes the specimen at the lowest point of the swing. After impact the bob rebounds from the specimen and continues swinging until reaches the rebound angle which is $\alpha_1 < \alpha_0$. Testing conditions were as follows: initial deflection angle of the pendulum

$\alpha_0 = 5^\circ$, bob radius $r_1 = 30$ mm, pendulum length $l = 1,5$ m. The damping swings of the pendulum were recorded for 20 s.

Tensile properties of textile materials and their fused systems were determined using automatic testing KES-F system. From the load/deformation curve tensile strain EMT (%) and tensile resilience RT (%) were determined. Resilience RT is the ratio of the tensile energy WT' defined as the area under textile material load-strain curve in recovering process and tensile energy WT defined as the area under textile material load-strain curve as it is presented in Figure 4. In order to compare experimental results obtained by two instrumental methods the correlations was defined between the parameters of tested materials impact behaviour and KES-F systems parameters.

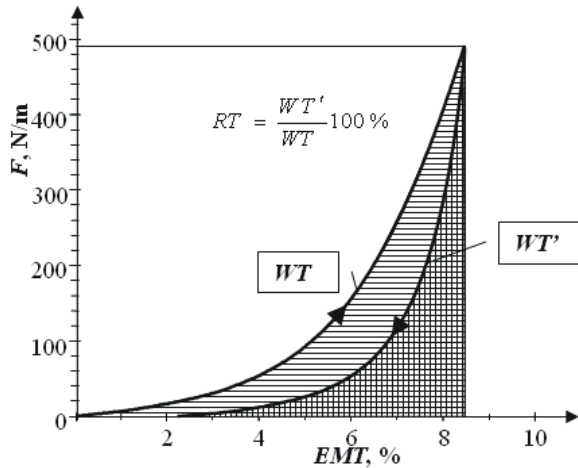


Fig. 4. Tensile load-strain curve in KES-F system

III RESULTS

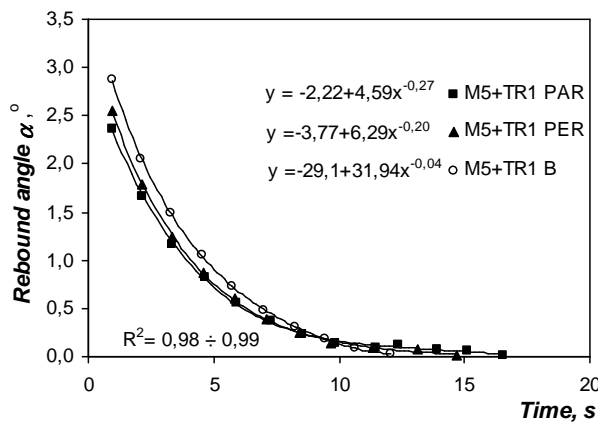
The investigations started with analysis of the effect of interlining orientation upon the impact behaviour of separate tested textile materials M5, P1 and TR1 and their fused systems. Former research works have shown that rebound α_1 and impact β_1 angles of the first pendulum swing can be used to characterise resilience properties of textile systems with required accuracy. Obtained results, error limits Δ , ° and variation coefficients ν , % are presented in Table 3, Figures 5 and 6.

The materials of higher resilience can be described by smaller impact angle β_1 and higher rebound angle α_1 , thus the resilience of interlining TR1 is higher compared to P1 interlining (impact angle β_1 is 19.2 % smaller and rebound angle α_1 is 17.5 % higher). Obtained results have also shown that rebound angle α_1 of fused systems with non-woven interlining P1 is smaller by 2,3 – 18,7 %, while deformation, i.e. impact angle β_1 is bigger by 4,3 % compared to fused textile systems with warp knitted interlining TR1. It means that tensile properties of interlinings play an important role determining tensile and resilience properties of the whole fused textile system.

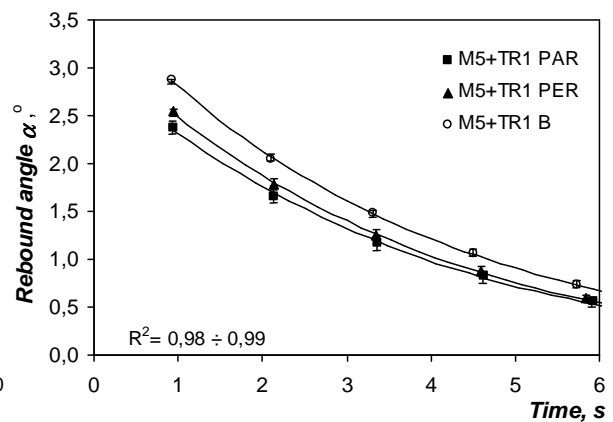
TABLE 3

RESILIENCE PROPERTIES OF TESTED TEXTILE MATERIALS AND THEIR FUSED SYSTEMS

Material and direction		α_1 , °	β_1 , °	α_1 deviation		β_1 deviation	
				Δ , °	ν , %	Δ , °	ν , %
M5		2.77	-0.53	± 0.04	1.02	± 0.01	0.56
P1		2.29	-0.52	± 0.13	5.35	± 0.01	2.21
TR1		2.69	-0.42	± 0.45	6.67	± 0.03	2.59
M5+TR1	PAR (0°)	2.37	-0.50	± 0.15	5.07	± 0.03	2.81
	PER (90°)	2.55	-0.49	± 0.07	2.20	± 0.01	0.41
	B (45°)	2.87	-0.47	± 0.02	0.62	± 0.02	1.48
M5+P1	PAR (0°)	2.00	-0.52	± 0.16	3.27	± 0.03	5.07
	PER (90°)	2.49	-0.50	± 0.18	5.67	± 0.03	4.92
	B (45°)	2.70	-0.48	± 0.22	6.68	± 0.02	3.78



a)



b)

Fig. 5. Decay process of pendulum rebound angles for M5 + TR1 fused textile system (a); enlarged view up to 5th rebound (b)

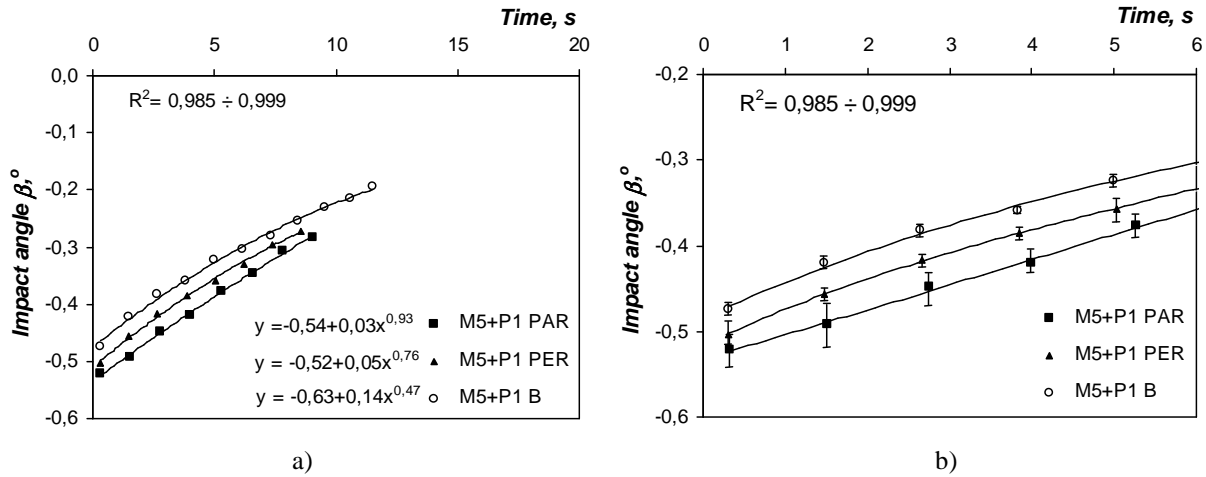


Fig. 6. Decay process of pendulum impact angles for M5 + P1 fused textile system (a); enlarged view up to 5th impact (b)

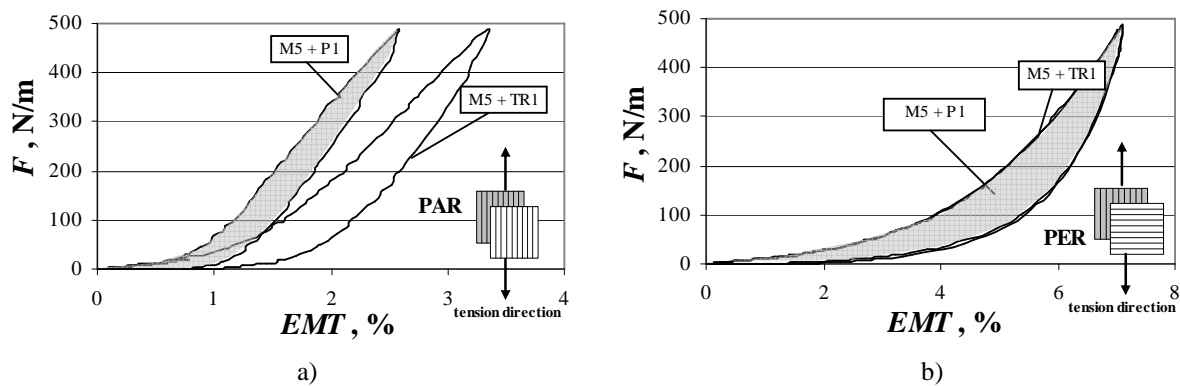


Fig. 7. KES-F results for: fused textile PAR systems M5 +P1 and M5 + TR1 with parallel orientated interlinings (a); fused textile PER systems M5 +P1 and M5 + TR1 with perpendicularly orientated interlinings (b)

The investigation of the effect of interlinings orientation upon fused textile systems resilience has shown that this property is the highest for systems B where interlinings are bias orientated (at 45°) in respect to outer fabrics warp direction. Rebound angle α_1 of such systems is the highest (Figure 5), while impact angle β_1 is the smallest (Figure 6). Resilience of fused textile systems with parallel orientation of P1 and TR1 interlinings (PAR systems) is the lowest because tensile strength of separate P1 and TR1 interlinings in longitudinal direction defined by KES-F system is the highest.

Besides, distinct difference (18.5 %) in resilience parameters express through first rebound angle α_1 between two fused systems (with P1 and TR1 interlinings) is observed for parallel orientated PAR systems. Meantime the same difference for fused systems with perpendicularly orientated interlining (PER systems) is not significant, i.e. it makes no difference which interlining can be chosen for fusing because resilience properties of both systems are almost similar.

Furthermore the results obtained by pendulum impact testing correspond to the results obtained by uniaxial tension in longitudinal direction with KES-F which have confirmed that tensile properties of selected fusible interlining have the highest influence upon tensile strain and resilience of PAR

systems (Fig. 7 a). While for PER systems tensile properties of interlining do not make significant difference (Fig. 7 b).

In the majority of earlier research works [11, 12] concerning biaxial deformation it was assumed that the tested material was isotropic and that the formed shell was an axi-symmetric surface. These cases are sufficiently idealised that they cannot be realised with such real materials as woven and knitted fabrics, because commonly these materials are characterised by one very stiff and the other – highly deformable – directions. The investigation of biaxial membrane and punch deformation modes showed that highly stretchable and anisotropic materials can experience the state close to the uniaxial tension (the state when one of the main stresses reaches its maximum value) and can form a thin non-axi-symmetrical surface with one less stresses direction [4].

In this respect the investigations of bilayered fused textile systems have revealed interesting phenomenon that the parameters of biaxial behaviour obtained in impact loading are related with the anisotropy of tensile strain EMT and tensile resilience RT determined by uniaxial KES-F testing (Table 4 and 5). Meantime it was interesting to obtain that the correlation of these parameters with EMT and RT defined in uniaxial longitudinal and transverse directions was low (R^2 varied between 0,26 and 0,76).

TABLE 4
TENSILE DEFORMATION *EMT* AND RESILIENCE *RT* OF FUSED TEXTILE SYSTEMS (KES-F RESULTS)

		<i>EMT</i> , %			<i>RT</i> , %		
		Long.	Trans.	Anizotropy	Long.	Trans.	Anizotropy
M5+TR	PAR	3,3	13,85	4,20	66,68	45,37	1,47
	PER	7,33	3,09	2,37	57,05	68,27	1,20
	B	6,68	9,91	1,48	57,72	52,25	1,10
M5+P	PAR	2,57	13,35	5,19	74,36	40,19	1,85
	PER	7,2	2,01	3,58	54,20	79,69	1,47
	B	3,39	6,79	2,00	62,48	52,4	1,19

TABLE 5
TENSILE WORK *WT* AND LINEARITY *LT* OF TESTED FUSED SYSTEMS (KES-F RESULTS)

		<i>WT</i> , Nm/m ²			<i>LT</i> , -		
		Long.	Trans.	Anizotropy	Long.	Trans.	Anizotropy
M5+TR	PAR	5,59	18,53	3,31	0,692	0,546	1,27
	PER	9,95	5,64	1,76	0,554	0,746	1,35
	B	10,34	19,65	1,90	0,632	0,810	1,28
M5+P	PAR	4,78	18,82	3,94	0,761	0,576	1,32
	PER	10,0	4,46	2,24	0,567	0,908	1,60
	B	6,30	16,47	2,61	0,758	0,991	1,31

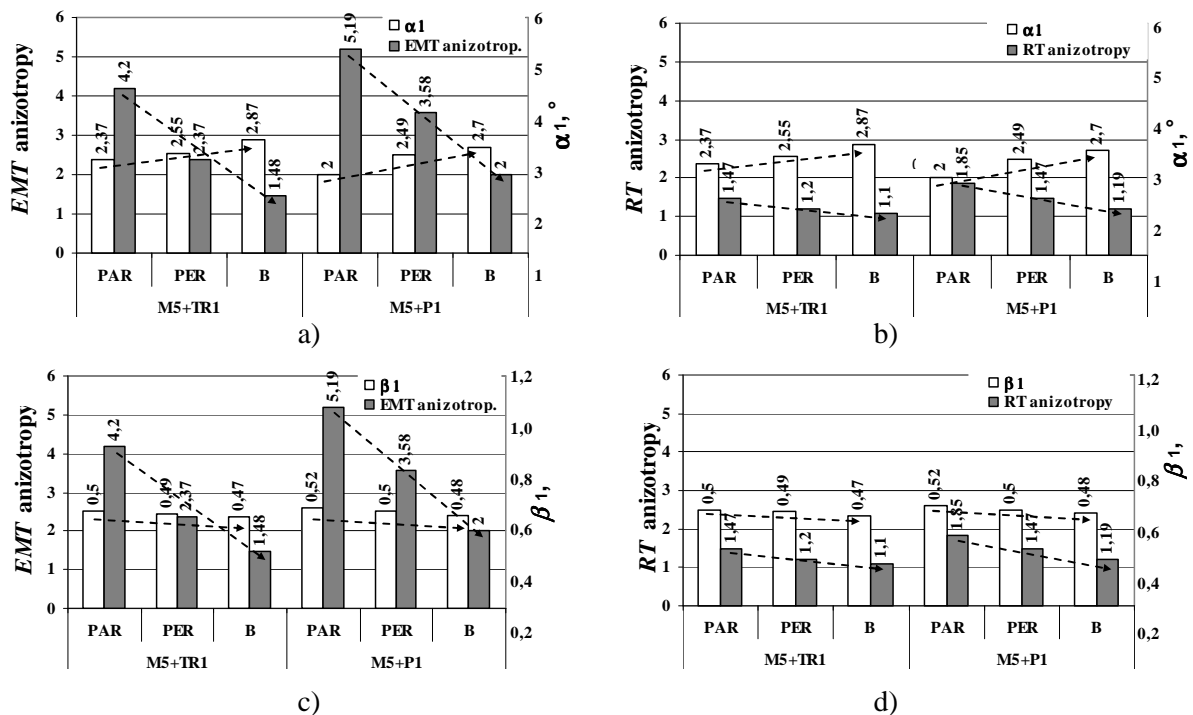


Fig. 8. The dependencies between fused textile systems impact behaviour and anisotropy of KES-F parameters: between rebound angle α_1 and tensile strain *EMT* (a), between rebound angle α_1 and tensile resilience *RT* (b), between impact angle β_1 and tensile strain *EMT* (c), between impact angle β_1 and tensile resilience *RT* (d)

The tendencies between biaxial pendulum impact and uniaxial KES-F parameters presented in Figure 8 show that the

increase of rebound angle α_1 and decrease of impact angle β_1 are closely related with the decrease of *EMT* and *RT* anisotropy (R^2 varies between 0,81 and 0,99).

IV CONCLUSIONS

The investigation of the effect of interlinings orientation upon fused textile systems resilience has shown that this property is the highest for B systems where interlinings are bias orientated in respect to outer fabrics warp direction. Meantime the resilience of PAR fused textile systems with parallel orientation of interlinings is the lowest because tensile strength of separate interlinings in longitudinal direction defined by KES-F system is the highest. These results correspond to uniaxial KES-F tensile testing results.

The parameters of biaxial impact behaviour of fused textile systems are related with the anisotropy of tensile strain EMT and tensile resilience RT determined by uniaxial KES-F testing, i.e. the increase of rebound angle α_1 and decrease of impact angle β_1 are closely related with the decrease of EMT and RT anisotropy.

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Kristina Ancutienė, Eugenija Strazdienė. Sakausētu tekstiliju elastīguma pētījumi.

Pētījuma mērķis ir izpētīt pamatnes orientācijas ietekmi uz sakausētu tekstiliju elastīgumu, kā arī novērtēt saistību starp sakausētu dublētu tekstiliju triecienizturību (divasu deformācija) un mehāniskajām īpašībām, kuras noteiktas ar automātisko KES-F sistēmu (vienass deformācija).

Tika pētīts virsējais audums un divu veida pamatnes audumi ar polimēra adhezīva slāni: neausta drāna ar gareniski orientētiem diegiem P1 un šķērsadīta trikotāža TR1. Sakausētās tekstila sistēmas tika veidotas, mainot pamatnes drānu diegu orientāciju attiecībā pret virsējā auduma šķēru virzienu: 0° (sistēma PAR), 90° (sistēma PER) un 45° (sistēma B). Sakausēto tekstila sistēmu elastīguma īpašības pētīja, izmantojot kompjuterizētu svārstu triecienizturības iekārtu. Stiepes īpašības pētīja, izmantojot KES-F sistēmu.

Pētījumi par pamatnes auduma orientācijas ietekmi uz sakausēto tekstila sistēmu elastīgumu parādīja, ka šī īpašība B sistēmām ir vislielākā. Sakausēto PAR sistēmu elastīgums ir viszemākais, jo pamatnes stiepes stiprība garenvirzienā, kā noteiktas ar KES-F sistēmu, ir visaugstākā. Tajā pašā laikā sakausētajām PER sistēmām nav svarīgi, kādas pamatnes izmanto sakausēšanai, jo abu sistēmu elastīguma īpašības ir gandrīz vienādas.

Divslāņu sakausētu tekstila sistēmu pētījumi parāda, ka divasu deformācijas parametri, kuri tika noteikti trieciena sloģojumā, ir saistīti ar stiepes deformācijas EMT un stiepes elastīguma RT anizotropiju, kura noteikta, izmantojot vienass testēšanu ar KES-F sistēmu, t.i., atlēciena leņķa α_1 palielināšanās un trieciena leņķa β_1 samazināšanās ir cieši saistīti ar EMT un RT anizotropijas samazinājumu.

Кристина Анцутiene, Евгения Страздиене. Исследование упругих свойств сплавленных текстильных систем.

В работе было изучено влияние ориентации подкладочного слоя (ПС) на упругость сплавленного текстиля, а также определена связь между ударной вязкостью (двухосная деформация) системы сплавленного текстиля и механическими свойствами, определенными автоматической системой KES-F (одноосная деформация). Исследована наружная ткань и 2 вида подкладочного слоя с полимерным адгезивом: нетканый материал с продольно ориентированными нитями P1 и основовязанный трикотаж TR1. Текстиль формировали меняя направление ориентации нитей ПС по отношению к наружной ткани 0° (система PAR), 90° (система PER), 45° (система B). Упругие свойства систем исследовали с помощью компьютеризированной установки ударной вязкости. Систему KES-F использовали для исследования свойств на растяжение.

Исследование влияния ориентации ПС на упругость системы текстиля показали, что эти свойства наилучшие у системы B. Упругость системы PAR наименьшая, так как разрывная нагрузка ПС в продольном направлении, определена с помощью системы KES-F, наивысшая. Для сплавленных систем PER нет разницы какой ПС выбран, так как упругие свойства в обеих системах практически одинаковы. Исследование двухслойных плавленных текстильных систем показали, что параметры двuosного поведения полученные при ударной нагрузке связаны с анизотропией деформаций при растяжении EMT и упругостью при растяжении RT определенной с помощью KES-F тестов. Увеличение угла отскока α_1 и уменьшение угла удара β_1 взаимосвязано с уменьшением анизотропии EMT и RT.