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Development of reinforced interlining materials to regulate elastic properties

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The present study is aimed at developing new interlining composite materials (RFI– reinforced fusible interlining), possessing optimum shaping characteristics with the required rigidity and elasticity, thus ensuring that volumetric shape of a garment will be preserved while wearing by a consumer. The original methods of forming a reinforcing polymer-fibrous composite have been developed to regulate the elastic properties of garments. It is proved that on the surface of interlining, there is chemical interaction between acrylate copolymers and polyamide adhesive. This ensures the formation of three-dimensional reinforcing structures of a unique bristle-like shape, encrusting the surface of the fibrous and penetrating their nano-porous system. The required values for elastic-deformation properties of polymer-fibrous composite materials can be found by changing the topology of applied polymeric modifiers and conditions of copolymerization. The new reinforced interlining materials ensure high molding ability of fused materials until the stage of final wet-heat treatment, during which the copolymerization of reinforcing and adhesive polymers, dense bonding of fused sample and fixing of shape are achieved. The results prove that the physical and mechanical properties of double-ply samples obtained with the use of RFI materials have higher indices in comparison to that of the levels of fusible interlinings. Hygienic properties are found to correspond to the standard ones that guarantee the comfort of the garment by the consumer. Thus, the new method helps to broaden the potential for successful commercialization of the reinforced interlining in fashion business.

Keywords*:* Acrylate copolymers, Elastic-deformation properties, Fusible interlining, Polyamide

1 Introduction

At present, the garment line of sewing products is variable. Most garments have a complex three-dimensional form, thus its creation and maintenance is an important technological task. To maintain this three-dimensional form, the material stiffness in the deforming sections should be increased. Interlining fabrics are used for this purpose.

They are usually invisible as they lie hidden between the shell fabric and lining, but their properties have a great influence on the shape, appearance, softness and durability of the clothes. The interlining is the component that improves their aesthetic and applicable properties of the clothes[1]. Depending on a design, one garment can contain up to twenty different types of interlining.

Interlining fabrics are used to support external fabrics as well as to create and maintain the beautiful three-dimensional (3D) shapes and drape of a garment[2]. With the increasing popularity of lightweight fabrics, the optimal combination of interlining and external fabric is becoming critical for garment quality. Careful selection of interlinings can compensate some of the shortcomings of external fabrics, but the use of poor or unsuitable interlining can lead to inferior quality garments, even when good quality outer fabrics are used[3]. The most popular in the garment industry are the fusible interlinings[4]. Fusible interlinings (FI) include a textile interlining web which is coated on one side with a glue polymer. The basic characteristics of fusible interlining are the type and structure of the supporting material used as a substrate, as well as the type and deposition of the adhesive. Types and structures of supporting material determine mechanical properties of the fusible interlining, and they have a high influence on final applicable properties of fused panels (shell materials with FI)[5]. During the design process, many concerns regarding the choice of suitable material arise because it must conform to the shape of the designed garment. The choice of FI is based on the purpose and three-dimensional form of the garment and the qualities of the shell fabric. When a stiffer form is designed and

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the softer shell fabric is used, the more load should be withstand by the interlining.

Current research refers to the problem that fusible interlining producing companies have not found the way to include all deformational and strength properties of interlining, changing according to the form, silhouette of the article and properties of the shell fabric. Considering modern requirements of ready-made products, fusible interlining should have limited stiffness considering a broad range of a higher discretization degree along with technological qualities; operating, hygienic, ergonomic indices and minimal level of material consumption. Except the increase in required flexural rigidity, the problem such as maintenance of quality of shell fabric and fusible interlining adjustment should be considered, while changing the form from flat to three-dimensional.

2 Theoretical Consideration

It is known that the change in the values of stiffness for each sample depends not only on the degree of plasticity of structure, but also on the dimensional characteristics. According to the degree of stiffness, the three-dimensional form of a garment is divided into soft-plastic, soft-fixed and frame-fixed.

To provide a variety of models, it is necessary to be able to change the stiffness of the material (*EI*) at shoulder and chest areas from 10×10^{-3} N·cm^2 (small soft-plastic three-dimensional form) to 40×10^{-3} N·cm^2 (large frame-fixed three-dimensional form). At the same time, it is necessary for the intermediate structure to provide a step of stiffness varying less than 3×10^{-3} Ncm^2.

Increase in rigidity leads to deterioration in the ability of the material to take bulk form. Therefore, t is necessary to correlate the changes in properties of shell fabric and fusible interlining during its transformation from the flat form to the three-dimensional state. Technological processes, where geometrical, physical and mechanical characteristics are changed, include following three basic stages:

(i) Fusing shell fabric with a fusible interlining by pressing machine,

(ii) Stitching samples on compound contours, so that one can obtain a three-dimensional form,

(iii) Final wet-heat treatment to create a final three-dimensional structure and fix it.

To produce a high quality garment with minimal manufacturing costs, the materials should have a great ability to obtain the required silhouette form and should have minimal stiffness on the first and the second technological stages. It is also necessary to have, at the final stage, the ability to fix 3D silhouette form with required stiffness parameters. Implementing these conditions is a necessity, but it is a technologically complex task. It is found possible to have a new method of producing reinforced fusible interlining (RFI), which differs from counterparts due to the particular “bristle-like” structure of inter-phase layer of polymer composite.

Modern methods of polymer chemistry allow receiving branched architecture of macromolecular compounds, called polymeric brushes. To increase the elastic-deformation properties of lining materials there is expedient to form these structures directly inside the fibrous material, filling its pore spaces [6].

As a textile liner web of RFI can use all types of the materials such as woven, nonwoven or knitted, it should be according to the elasticity of shell fabric and its laminate with an interlining. Figure 1 shows the technology of producing RFI on knitted material base.

The RFI material consists of the knitted textile liner web (**1**), with two types of polymer such as a hot-melt glue polymer (**2**), and a reinforcing polymer (**3**). The combinations used for polymer preparation are chosen according to their chemical resistance at certain period of a manufacturing process. For this, both products should have final reactive clusters (shown in the scheme by symbols ∿• and ⊸) on the flexible-chain adhesive and rigid-chain reinforced polymer macromolecules. Regular spotting of the glue polymer to the textile liner web is preferred.

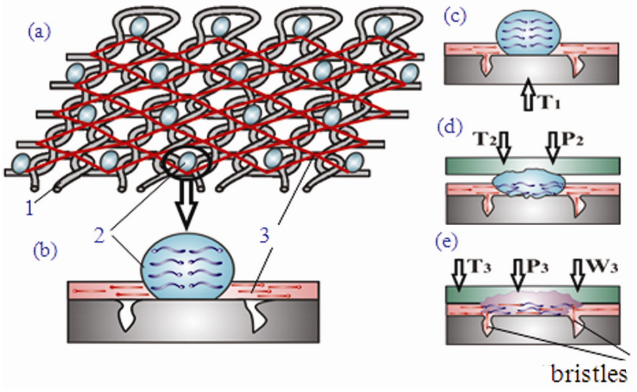

Fig. 1 — View of reinforced interlining material (RFI) and its interaction with shell fabric [**(1)** textile liner web, **(2)** hot-melt glue polymer, **(3)** reinforcing polymer]. **(a)** – view of RFI, **(b)** – schematic layout of RFI cross-sections, **(c)** – RFI on the stage of drying of the material, **(d)** – shell material and RFI on the stage of fusing, and **(e)** – fused materials on the stage of wet-heat treatment

The reinforcing polymer is applied with a screen printing method.

Schematic layout of material cross-sections [Figs 1 (b)-(d)] allow visualization of the change in a polymer component condition during the manufacturing process. The process begins with putting the reinforcing polymer dispersion on the textile liner web with discretely distributed thick drops of glue polymer [Figs 1 (a) & b)].

The choice of polymer preparations and each of the consecutive stages of the process have great importance. Drying of the material [Fig. 1 (c)] is achieved at the temperature $T_{1,}$ which is less than the melting point T_m^{GP} of a glue polymer ($T_1 < T_m^{GP}$). As the dispersion of reinforcing polymer is in liquid-phase, the dispersion penetrates into the submicroscopic pores of fibrous material and a macromolecule active center orientation takes place at the phase boundary with glue polymer formation.

The stage of fusing the shell fabric with a fusible interlining takes place at the temperature higher than T_m^{GP} , which should not reach at reinforcing polymer activation reaction temperature T_p^{RP} ($T_m^{GP} \leq T_2 < T_p^{RP}$). It provides the conditions for adhesive macromolecule, spatial refocusing to reinforcing polymer active centers with hydrogen bond formation among clusters, for example

$$R_1\text{-}C(OH){=}O\cdots H\text{-}NH\text{-}R_2 \text{ or } R_1\text{-}C(O)\text{-}OH\cdots NH_2\text{-}R_2$$

A certain level of holding pressure (P_2) provides dot penetration of the melting, but rather thick glue polymer into inter-fibre spaces of interlining and shell fabric. Presence of molding ability and an insignificant increase in stiffness have great importance at this stage. Finally, wet-heat treatment of a three-dimensional form of a garment was given. Solid adhesion of sticking materials as physio-chemical reaction and their reinforcement should be done to maintain the stability of three-dimensional forms under external loading.

In the developed technological process [Fig. 1 (e)], fixing is accomplished under the conditions of steam pressing and the ideal pressure (P_2) displaces air gap between materials, flattens a hot-melt glue polymer and increases adhesion of fastening layer. Degree of wetting (W_3) and heating at temperature T_3, higher than that of reinforced polymer activation reaction temperature ($T_3 > T_p^{RP}$), provides interpenetration of polymer and chemical interaction of their active centers. As a result, the garment to be formed is a composite with a developed boundary layer of copolymer binding. Along with that, due to the reinforcing polymer penetration into submicroscopic pores of interlining, the boundary layer has a "bristle-like" structure. These "bristles", stuck in the blended polymer layer with an outer end, give the material elastic properties. This study identifies the conditions for producing new interlinings (RFI) and their technical capacity to regulate elastic-deformation properties of the garment.

3 Materials and Methods

3.1 Materials

Three types of shell materials (polyester) for suits (SM 1, SM 2, SM 3) and two types of fusible interlinings (FI 1 and FI 2) were used. Characteristics of shell fabrics and fusible interlinings studied are described in Tables 1 and 2.

As a reinforcing component, the perspective products of acrylate water dispersion DPA-1 and DPA-2 were used. Characteristics of reinforcing polymer dispersions studied are described in Table 3.

Table 1 — Characteristics of shell fabrics (polyester)

Fabric	Thickness mm	Number of yarns in 10 cm		Surface density g/m^2	Stiffness (EI) ×10^{-3} N·cm^2		Elasticity %	
		Warp	Weft		Warp	Weft	Warp	Weft
SM1	0.58	780	328	280	1.82	1.31	75	40
SM2	0.30	344	352	183	0.78	0.51	50	45
SM3	0.35	364	296	163	0.51	0.77	45	35

Table 2 — Characteristics of fusible interlinings

Interlining	Fibre	Type of web	Type of glue (polyamide) covering	Surface density, g/m^2	Thickness mm	Fusing temperature, °C	Shrinkage %
FI 1	Polyester	Nonwoven	Irregular, spotting	45	0.3	120-140	0.2-0.6
FI 2	Viscose/polyamide (64/36)	Knitted	Irregular, spotting	60	0.4	130-140	0.2-0.6

3.2 Methods

Polymer composite material was made using the reinforcing polyacrylate dispersion DPA and thermal melting polyamide glue by individual and two-component film casting. Two-component films have been prepared from homogeneous polymer mixtures in a weight ratio of 1:1 and after air-drying through thermo-co-polymerization at 125°C. Spectral analysis of the films was performed by the multiple frustrated total internal reflection (FTIR) method (AVATAR 360 FT-IR ESP).

3.3 Sample Preparation

The process of sample preparation includes a set of sequentially implemented operations as shown below:

(i) RFI production – Samples of fusible interlining material were coated with reinforcing polymer DPA-1 or DPA-2 dispersions by screen printing method with diamond-shaped indentation that have the specific material surface coverage value 0.55 and dried at ambient temperature.

(ii) Fused samples (SM+FI or SM+RFI) production – It was done on the transmission-type thermo press Japsew SR-600 (China), at a temperature of 80 – 160 °C.

(iii) Moist-heat treatment of fused samples – It was performed at 125 °C for 30 s to solidify polymeric binder and to form a fibrous polymer composite material.

3.4 Test Methods

3.4.1 Bond Strength

The quality of a fused sample is estimated by its bond strength, mechanical properties (extensibility, shear and bending properties), dimensional stability after fusing, washing or chemical cleaning, surface appearance and ability to form into 3D structure [5]. The bond strength was estimated by measuring the force required to separate the interlining and shell fabric[8].

3.4.2 Drapability

Investigating the 3D behavior of fused parts of the garment is very important and is one of the basic criteria 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[9]. Drapability is a phenomenon which arises when a fused sample or shell fabric hangs down over a circular pedestal without the use of external force[10]. The objective drape evaluation was done by measuring the variety of drape parameters, i.e. drape coefficient, depth of folds, the number of folds and distribution of folds[5,11,12]. Indicator of drapability was designated in accordance with methodology as described earlier[5].

3.4.3 Stiffness

The stiffness of textile liner and fused sample was calculated in accordance with GOST RF 10550-93 using contactless console methodology and the device PT-2 (Fig. 2). The strips of material (size 160 × 30 mm) were placed horizontally on the top side of the machine and pressed by 20 mm load in the middle. After that the sides of anchor were dropped down, the ends of material hanged loose due to gravitational force. After a minute, the amount of overhang of the strips ends was measured. The value of stiffness EI ($\times 10^{-3}$ N·cm^2) was calculated using following formula[1]:

$$\mathrm{EI} = \frac{42.046m}{0.5755f^3 - 2.411f^2 + 8.502f} \qquad \dots (1)$$

where m is the mass of material strip in gram.

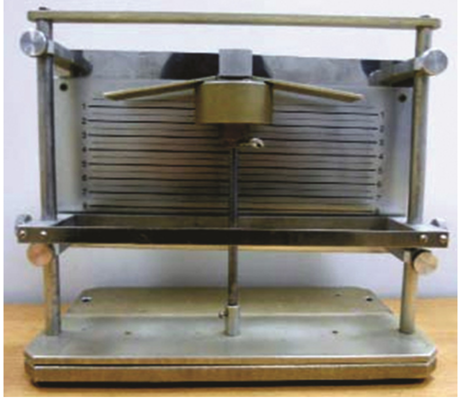

Fig. 2 — View of the device PT-2

Table 3 — Characteristics of reinforcing polymer dispersions

Dispersion	Composition	Dry solids weight ratio, %	*p*H	Dynamic viscosity (μ) , mPas
DPA-1	(met) Acrylic monomers co-polymer	55	5 - 7	9.8
DPA-2	Acrylic acid and styrol co-polymer, stabilized by anionic surfactants	50	7.5 – 8.5	40.9

3.4.4 Elasticity

The elasticity was calculated using ring method in accordance with GOST RF 10550-93. A sample (95 × 20 mm) was clamped on the removable site. The top surface of the sample was outside. The sample should take the form of correct ring. Then it was loaded up to the sample sagging of 1/3 of diameter (S_o=30 mm) during 30 s. After load breaking the sample was laid off during 30 s and the residual deflection S_1 was measured. The value of indicator was calculated using the following formula[2]:

$$У = \frac{S_o - S_1}{S_o} \cdot 100\% \qquad \ldots (2)$$

3.4.5 Bonding Strength

The bonding strength test was conducted in accordance with GOST USSR 28832-90 - materials for interlinings with thermoplastic coating. Method for determination of bonding strength along with the sample preparation and conducting tests were realized in accordance with the ASTM D 2724 standard under the conditions, such as sample size 150 × 30 mm, size of unglued piece 40 mm, distance between clamps 50 mm, and speed of moving motile clamp 100 mm/min. The bonding strength (R, N/10 cm) was calculated using the formula R=P/300, where P is the average value of the force required to separate the interlining and shell fabric.

3.4.6 Thickness and Molding Ability

The thickness was conducted in accordance with the ISO 5084:1996 standard. The molding ability characterizes the relative size of the material or fused samples, which represents the three-dimensional surface. It was conducted in accordance with the method given in a patent RF № 234347 - method of measurement of molding ability of textile liner. For determination of molding ability, the sphere piece with diameter 150 mm was kept on the tripod and then fixed on the stand. The sample of the size 350 × 350 mm was placed above the sphere. For ensuring a close fit of the material to the sphere, folds of the same depth were made in the warp and weft directions. Measurement scheme is shown in Fig. 3. The 'moulding ability' (MA) was calculated using following formula[3]:

$$\mathrm{MA} = \frac{\alpha}{\alpha_{\max}} \cdot 100\%, \qquad \ldots (3)$$

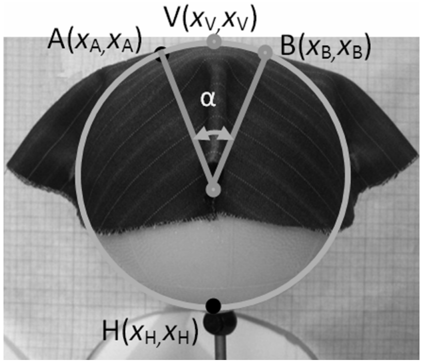

Fig. 3 — Measurement scheme of central angle of recurrence (α)

where α is the central angle of recurrence by material in degree; and $\alpha_{\max}$, the maximum possible angle of recurrence ($\alpha_{\max}$ = 180°) in degree.

By contactless methods of measurement, the coordinates of the top point $V(x_V,y_V)$, the lower point $H(x_H,y_H)$, and the bordering points $A(x_A,y_A)$ and $B(x_B,y_B)$, to which the sample fully repeats the surface of the sphere, were detected. Then the central angle of recurrence (α) was calculated as an angle between AO and BO, which connect the bordering points of the surface of recurrence and the center of the sphere (O).

3.4.7 Breaking Load and Elongation at Rupture

Breaking load and elongation at rupture tests were conducted in accordance with ISO13934-1:2013 Textiles - Tensile properties of fabrics (Part 1) - Determination of maximum force and elongation at maximum force using the strip method.

3.4.8 Air Permeability, Hygroscopic and Water Repellency

Air permeability was conducted in accordance with GOST 12088-77 – Textile Materials The methodology corresponds to ASTM D737 standard test method for air permeability of textile fabrics. Measurements were conducted under the conditions, such as rarefaction under dotty sample 49 Pa and jaw level for dotty sample 147 N. Air permeability (AP) ($m^3/s\ m^2$) was calculated using formula $AP=V/S$, where V is the average volume of air (m^3/s); and S is the measurement area (m^2).

Hygroscopicity and water repellency were conducted in accordance with ISO 811-81 Textile Fabrics.

4 Results and Discussion

The principal point of elaboration is that the interaction between a reinforcing and adhesive polymer should not reduce the adhesion-cohesion connection between the interlining material and the shell fabric during the fusing process. The chemistry of the adhesive interaction involves the formation of multiple hydrogen bonds between fibre-forming and binding polymers. The reaction should be carried out only between the end clusters, without the functional groups interfering on medial parts of the polymer chain of the adhesive material. It is found that, in order to guarantee interaction of such polymer materials as an adhesive compound, it is desirable to use blended polymers on polyamide and/or polyacrylic base and for a reinforcing polymer - textile auxiliaries on the polyacrylic and polyurethane base. The interaction of polymer components of reinforced interlining is proved by the results of IR-spectroscopic studies.

Figure 4 shows the spectrogram of polyamide glue (a), polyacrylate dispersion (b), and polyamide-polyacrylate composite (c). The analysis shows that the key changes take place while reducing the intensity of stretch vibration bands of amides N-H-linkage at 725 cm^{-1} (ref. 13). A quantitative estimation of the spectra obtained has been conducted in accordance with the calibration of 'base line method and objects' by the internal standard band. The base line was taken through lowest absorption at 1985 cm^{-1} and 465 cm^{-1}, because measurements were conducted considering the ratio of optical density of close lying bands. An internal standard was used considering a band of valence vibrations of N-H linkages in imide groups at 1650 cm^{-1}. This band is intensive and has minimal deviations; therefore it defines overall content of polyamide component in the analyzed objects. The analysis shows that at the stage of composite formation, the content of amino-end groups in the polyamide adhesive reduces by 2.7 times. Therefore, the spreading of absorption band at 1750 cm^{-1} is determined by the change of cluster surrounding C=O. This proves the occurrence of that poly-condensation reaction, with the formation of a covalent link between amide-end groups of glue and carboxyl groups of poly-acrylate dispersion.

It is observed that the characteristic spikes of all functional clusters of the original components are shown on a spectrogram of reaction product. Thus, a reinforcing polymer does not block carbonyl and imide clusters in molecules of polyamide components.

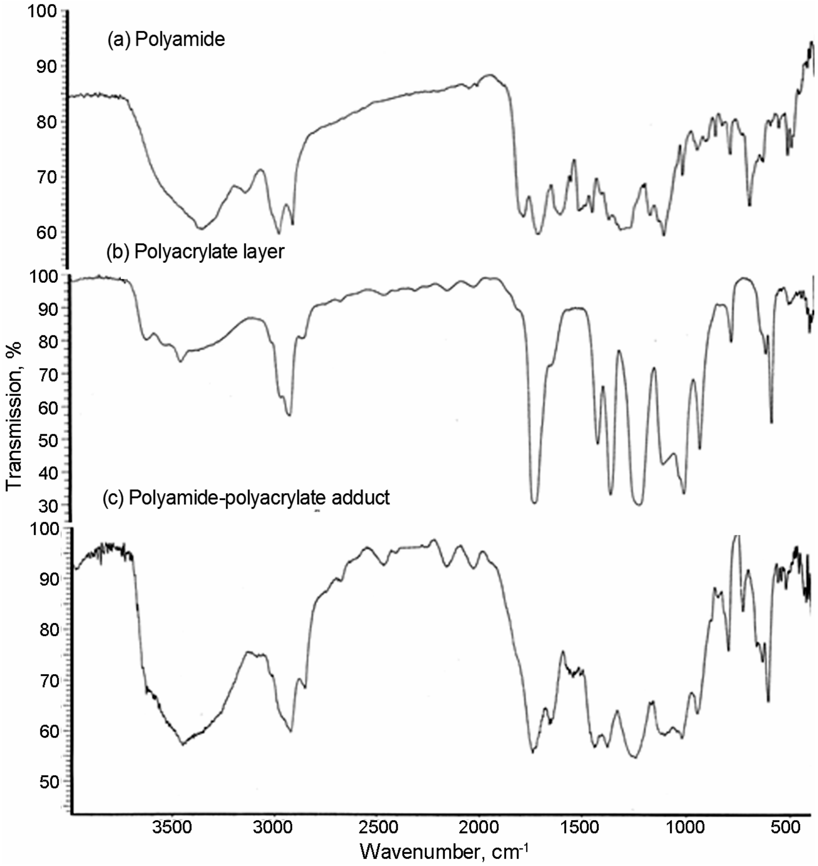

Fig. 4 — Spectrograms of (a) polyamide adhesive, (b) dispersion DPA-1 and (c) polyamide-polyacrylate adduct

The reaction of a blended polymer does not reduce the ability of adhesive material to form multiple hydrogen bonds with functional clusters of textile materials.

The original compositions of the reinforced component were developed to obtain RFI materials [*Russian Federation Patent No. 2383672*]. By using this technology, innovative methods of regulating elastic deformation product properties by forming three-dimensional self-organizing structures of reinforced polymer in interlining material is realized.

The addition of the reinforcing polymer into the structure of interlining material should not hinder the formation process of a sample, which is produced by its fusion with the shell fabric of the garment.

The stiffness and the molding ability of the fused samples have been investigated. The degree of melting of the glue depends on the temperature of the heating surface and the residence time in the heating zone. Therefore, samples were prepared at the maximum speed of the material movement at a temperature of 60 – 160 °C.

It is found that the stiffness increases sharply at the temperature 115 °C while at 140 °C it reaches a constant value. At the same time, at the fusing temperature of up to 120°C, the moulding ability of panel decreases (not more than 10 %) insignificantly and does not reach the level of critical value (MAcrit = 16.5%) (Fig. 5). Further increase in fusing temperature provides sudden decrease in molding ability and increase in flexural rigidity.

An ideal temperature range 100 – 125 °C guarantees melting of glue coating and preliminary sticking of coupled materials; the adhesion strength is enough to prevent the layers from separating while further processing of a garment (the bond strength of SM and FI = 0.15 – 0.25 N/10 cm). At the same time, complete adhesion of materials is not allowed to achieve, and a certain level of their fusion is kept to obtain a necessary three-dimensional garment form.

The desired flexural rigidity and the separating force of adhesion bond have been achieved during the wet-heat processing, which is conducted after giving the bulk shape of the product. Study on adhesive bond of developed reinforced interlining materials with different types of garment shell fabric shows that the separating force of adhesion bond increases. Table 4 shows the mechanical strength at uniaxial tension of the interlining. The reinforcing technology causes an increase in breaking load by 1.3 – 2.5 times, while increase in elongation at rupture index by 1.25 – 1.65 times. So, the indices of reinforced interlining materials of on nonwoven textile liner web (FI 1) are not found inferior to the indices of reinforced interlining materials on knitted textile liner web (FI 2). Reinforced materials of the nonwoven textile liner web have the highest increase in strength; they are distinguished by a low level of initial strength and small thickness. The polymer composition binds the material with interconnected branches penetrating the microscopic pore structures of fibres of the textile liner web.

While processing the textile liner web of fusible interlinings with reinforcing polymer the change in the strength of not only the reinforced material, but also the fused samples takes place, (Table 5).

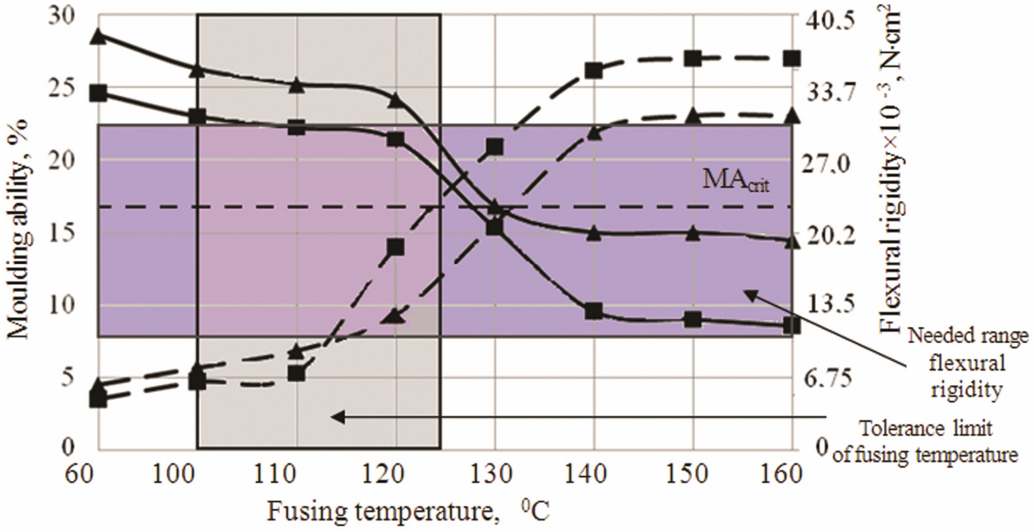

Fig. 5 — Effect of fusing temperature on the molding ability and flexural rigidity of fused samples [(—) Moulding ability, (– –) Flexural rigidity]

Table 5 shows the increase in bond strength for the laminate of shell fabric and an interlining on knitted textile liner web (RFI on FI 2 base) in comparison with a reinforced analogue (FI 2) by 15 – 35% and for the laminate of shell fabric and an interlining on nonwoven textile liner web (RFI on FI 1 base) regarding the analogue (FI 1) by 45 – 65%. The effect obtained is due to the influence of reinforcing polymer on the condition of adhesive material layer and hardening of a boundary layer.

The selection of processing method to produce reinforced composite materials creates an extended range of new interlining materials for all types of garments on the base of a limited number of textile liner webs. The discretization degree in the change of stiffness values of fused samples of the garment is increased by 3 – 6 times together with the required increase of elasticity index. A spectrum of applications of the reinforced interlining materials is shown in Table 6.

The use of the reinforced interlining materials allows the laminate (of shell fabrics and interlining) to have with a wide range of variations in elastic-deformation properties and good hygienic characteristics (Table 7).

Represented results prove that the physical and mechanical properties of double-ply samples obtained with the use of RFI materials have higher indices in comparison to that of the levels of fusible interlinings. Hygienic properties are found to correspond to

Table 4 — Strength characteristics of unmodified analogues FI and RFI

Interlining	Direction of load application	Breaking load (Bl) N/cm		ΔBl, %	Elongation at rupture (Er) %		ΔEr, %
		FI	RFI		FI	RFI	
FI 1	Lengthwise	0.40	0.92	130	32	40	25
	Grain cross	0.16	0.41	156	51	65	27
FI 2	Lengthwise	0.62	0.81	31	38	51	34
	Grain cross	0.30	0.41	37	29	40	38

Table 5 — Bond strength of fused sample of shell material (SM) and interlining (FI and RFI)

Base interlining type	Reinforcing dispersion	Shell fabric	Bond strength of a fused sample (BS), N/10cm		ΔBS, %
			FI	RFI	
		SM 1	0.37	0.55	45
FI 1	DPA-1	SM 2	0.45	0.74	62
		SM 3	0.41	0.68	65
FI 2	DPA-2	SM 1	0.50	0.58	15
		SM 2	0.54	0.72	32
		SM 3	0.52	0.71	35

Table 6 — Characterization of RFI line

Groups of garments	Textile liner web		Number of RFI articles	Flexural rigidity (EI) $\times10^{-3}$, N·cm^2	Δ EI $\times10^{-3}$ N·cm^2	Elasticity %
	Woven	Fibre				
Coat-suit	Knitted	Natural Artificial Synthetic	20 – 25	2.75 – 16.4	0.68	75 – 95
	Nonwoven	Artificial Synthetic				
Corsetry cloth	Knitted	Natural Artificial	15 – 20	16.41 – 41.2	1.3	80 – 100
	Nonwoven	Artificial				
Technological (furniture, bags, hats, shoes)	Knitted or nonwoven	Artificial Synthetic	18 – 22	41.2 – 110.0	3.1	50 – 100

Table 7 — Characterization of physical, mechanical and hygienic qualities of fused samples

Property	Index value [a]											
	FI 1			RFI on the FI 1 base			FI 2			RFI on the FI 2 base		
	SM1	SM2	SM3	SM1	SM2	SM3	SM1	SM2	SM3	SM1	SM2	SM3
Thickness, mm	1.76	1.9	2.1	1.75	1.85	2.05	1.76	1.8	2.0	1.75	1.8	2.0
Flexural rigidity $(EI)\times10^{-3}$, N·cm^2	1.6	3.4	4.6	8.9	7.8	11.8	3.1	6.3	9.8	7.1	12.5	15.3
Discretization degree $(\Delta EI)\times10^{-3}$, N·cm^2		2.1			0.6			2.1			0.6	
Elasticity, %	40	45	45	65	70	70	55	60	60	75	80	85
Coefficient of drape	0.57	0.62	0.53	0.62	0.67	0.57	0.46	0.48	0.42	0.54	0.60	0.52
Air permeability m^3/h m^2	51.4	55.3	53.7	50.8	54.3	52.1	64.7	65.3	63.4	64.3	64.8	62
Hygroscopicity, %	4.5	4.4	4.6	4.3	4.2	4.4	4.1	4.3	4.4	4.0	4.1	4.2

[a] Laminate of interlining materials and different types of shell fabrics.

the standard ones that guarantee the comfort of the garment by the consumer. Thus, the methods presented broaden the potential for successful commercialization of the reinforced interlining in fashion business.

5 Conclusion

In this study by the IR spectroscopy method, the effect of copolymerization of reinforcing polyacrylate and adhesive polyamide component of the composite material without deteriorating the adhesive properties has been confirmed. The studied chemical preparations and the technological process ensure the formation of a three-dimensional reinforcing structures of a unique bristle-like shape, encrusting the surface of the fibres and penetrating into their nanoporous system. The required values for elastic-deformation properties of polymer-fibrous composite materials for various kinds of textile carriers are found by changing the topology of applying polymeric modifiers and conditions of copolymerization.

The new reinforced interlining materials ensure high molding ability of fused materials until the stage of final wet-heat treatment, during which the copolymerization of reinforcing and adhesive polymers, dense bonding of fused sample and fixing of shape, are achieved. The discretization degree of the change in stiffness values of fused samples of the garments is increased by 3 – 6 times together with the required increase of elasticity index. The bond strength of fused materials is increased by 1.3 – 1.6 times; the stability of structure to the deformation and physicochemical impacts is improved.

A wide range of variation in elastic-deformation properties makes it possible to adapt quickly the assortment of interlining materials to the individual customer requirements taking into consideration the purpose of the manufactured clothing and characteristics of the shell materials.

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