

# Aesthetic Aspects of Clothing Products in the Context of Maintenance Procedures

The Radom Technical University  
Department of Shoes  
and Clothing Materials Technology  
ul. Chrobrego 27, 26-600 Radom, Poland

## Abstract

To improve the aesthetics of clothing (jackets), special insert materials are used during production. During usage, clothing comes into contact with various factors (physical, chemical, mechanical and biological ones) which cause deformation and wear. In order to better examine the effect of maintenance treatment on the quality of laminates created by gluing materials, this work was limited to the determination of the influence of the 5<sup>th</sup> procedure ( $M_{pr} - 5$ ), consisting of dry cleaning + ironing, on the value of flexural stiffness index  $G$  depending on  $m$  – quantity (mass) of deposited adhesive (glue),  $D_1$  – the direction in which the deposited layers are placed, and  $D_c$  – the direction in which samples were cut out. The examinations carried out indicated that the above mentioned maintenance treatment entails reduction of flexural rigidity. It may be caused by the partial washing out of the surface fabric finish.

**Key words:** clothing laminates, polymers, adhesive joints, flexural stiffness, maintenance procedures.

In order to improve the aesthetic qualities of the product, different inlayer materials [5 - 7] are used during clothing production. These are usually woven, knitted or unwoven fabrics, with a layer of thermoplastic adhesive. The type of inlayer depends, among others, on the outer material properties, the purpose for which the product is used and the place where strengthening is required e.g. collar, lapels, front, lower sleeve parts (Figure 1).

In use, clothing products are affected by different factors (physical, mechanical, chemical and biological) which lead to deformation of shape and product wear [8]. Also, maintenance processes

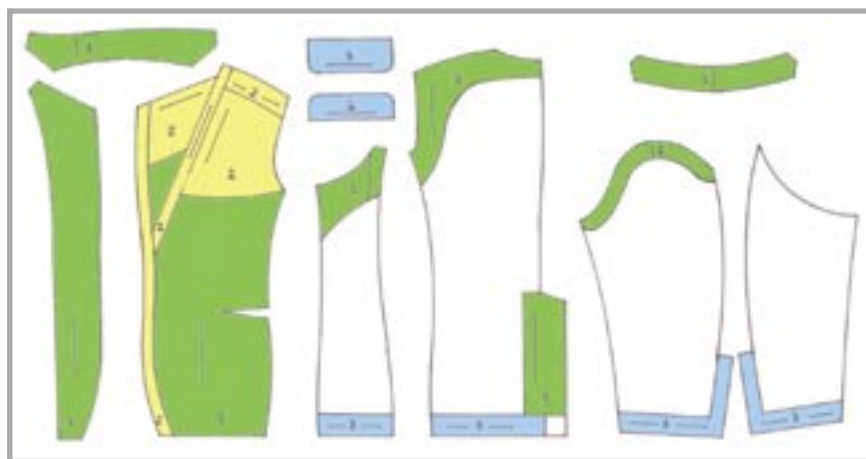
like dry cleaning or washing in water often contribute to the deterioration of shape durability of particular clothing elements. The clothing wearer requires aesthetic qualities to be retained both before and after maintenance procedures.

In order to better examine the effect of maintenance treatment on the quality of laminates created by gluing materials, this work was limited to the determination of the influence of procedure ( $M_{pr} - 5$ ) [12], consisting of dry cleaning + ironing, on the value of flexural stiffness index  $G$ , which depends on the value of mass ( $m$ ) of the deposited adhesive (glue),  $D_1$  – the direction in which the de-

## Introduction

In recent years interest in products made from natural fibres (flax, hemp) has increased. These materials have many properties favourable for human health and well-being. These are high hygroscopicity and anti-bacterium qualities; they do not cause allergies and lack of electrostatic characteristics [1, 2]. The basic drawback of flax (linen) fabrics is their creasing which does not allow them to be used for some clothing products, for example jackets.

In the production process of fabrics, different methods are used to reduce creasing. Yet, they do not provide proper shape durability of different elements [3, 4].



**Figure 1.** Various placement of insert in the jackets — direction of the warp of insert; 1) 0-0° (warp – warp), 2) 0-45° (warp – angle), 3) 0-90° (warp – weft).

**Table 1.** Fabric characteristics.

Fabric type	Composition	Weave	Surface mass, g/m <sup>2</sup>	Number of threads of warp/ weft, number of threads/dm	Mass of warp/weft, tex
linen-cotton mix B	warp - 52.8% linen	plain weave	210	260	50
	weft - 46% cotton /1.2% of surface PU			180	50/2.5

**Table 2.** Characteristics of the knitted clothing inserts. Weft insertion in a warp-weft knitted fabric.

Insert symbol	Composition	Density /dm		Surface mass, g/m <sup>2</sup>	Amount of applied adhesive, g/m <sup>2</sup>	Type of polymer	Number of polymer points
		vertical	horizontal				
PA - 12	polyester/viscose 44 dtex/40 tex	120	110	72.0	Paste = 12.0	copolyamide	CP46
PA - 16	polyester/viscose 44 dtex/40 tex	120	110	76.0	Paste = 16.0	copolyamide	CP46
PA - 20	polyester/ viscose 44 dtex/40 tex	120	110	80.0	Paste = 20.0	copolyamide	CP46
Pp -13 „double spot”	polyester/ viscose 44 dtex/40 tex	120	110	73.0	Paste = 6.0 Powder = 7.0	modified polyethylene, low pressure + copolyamide	CP46

posited layers are placed,  $D_c$  - the direction in which the samples were cut out.

## Research methodology

### Experimental material

The following fibre materials were examined:

- woven fabric for suits, produced by the Fabryka WYROBÓW LNIANYCH in Żyrardów, and
- knitted clothing inserts - experimentally developed insert materials, made by Cloth Industry Manufacturing Company „Camela” S.A. from Wałbrzych (Tables 1 and 2).

To the inserts marked as PA, various amounts of thermoplastic adhesive – copolyamide – were applied, from 12 to 20 g/m<sup>2</sup>. The insert marked Pp was treated with 13g/m<sup>2</sup> of thermoplastic adhesive, the so-called “double spot”. This adhesive consists of two polymer types - modified low pressure polyethylene and copolyamide.

### Preparation of the laminates for experiments

Three variants of the laminates were prepared for experiments (Figure 2), with the following  $D_1$  of the individual layers:

1. 0-0°, warp – warp
2. 0-45°, warp – angle
3. 0-90°, warp – weft

In each of the variants the upper fabric was placed in the same direction as the warp, that is, at a 0° angle. The textile inserts were placed in three directions: on the warp – 0°, on the bias – 45° and on the weft – 90°. The adhesion process was executed on a plate press, with predefined adhesion parameters:  $T = 140^\circ\text{C}$ ,  $t = 13\text{ s}$  and  $p = 3.5\text{ N/cm}^2$ . Next, the laminates prepared in this way were cut into swathes, and based on the warp of the top fabric in three directions, that is,  $D_c = 0, 45, 90^\circ$ , according to the requirements of the flexural stiffness  $G$  determination [9].

Where  $D_c$  is the angle between the warp of the top and their weft.

### Maintenance procedures – $M_{pr}$ (dry cleaning + ironing)

Dry cleaning was performed in dry cleaning aggregates using perchloroethylene. After dry cleaning, the samples were ironed in conditions presented in point 2.2. Stability of the stiffness index value was examined before ( $M_{pr} - 0$ ) and after 5 maintenance procedures ( $M_{pr} - 5$ ).

### Analysis of examination results

In order to determine the effect of the fifth maintenance procedure ( $M_{pr} - 5$ ) on the value of the determined flexural stiffness index of clothing laminates intended for men's jackets, the following experiments were carried out. The experiments were conducted in accordance with a research programme developed on the basis of three-factor and two-factor plans of the 3<sup>3</sup> and 2<sup>3</sup> plans [10, 11].

The usage of the standard experiment plans was preceded by factor coding according to this formula:

$$\text{Coding value} = (\text{physical value}) + \frac{(\text{central value}) - (\text{physical value})}{\text{changeability unit}}$$

Assessment of the regression functions describing relationships between the factors and properties examined was carried out with the help of a SAS computer programme.

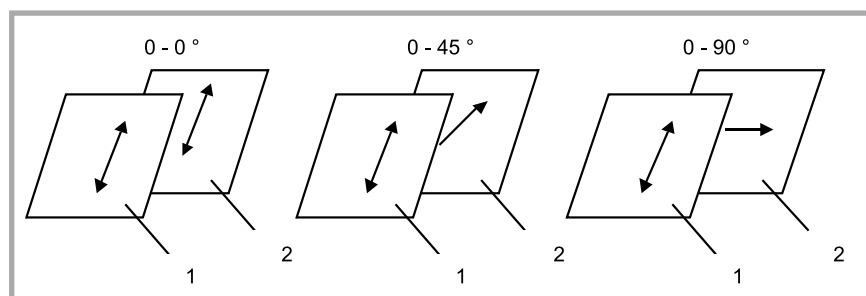
**Experiment 1** developed on the basis of a three-factor plan 3<sup>3</sup> with input factors:  $X_1$  – PA adhesive mass  $m$  in g/m<sup>2</sup>,  $X_2$  – direction of layer arrangement with respect to one another  $D_1$  in °,  $X_3$  – direction in which samples were cut out  $D_c$  in °. On the basis of preliminary examinations, factor changeability ranges were determined (Table 3).

**Experiment 2** was carried out on the basis of a two-factor plan 2<sup>3</sup> with input factors:  $X_1$  – direction of layer arrangement with respect to one another  $D_1$  in °,  $X_2$  – direction in which samples were cut out  $D_c$  in °. Factor changeability ranges were determined on the basis of preliminary examinations (Table 4).

For the changeable factors selected the following codes were used:  $X_1, X_2, X_3$ . Central and changeability values were determined for them.

After considering regression coefficients  $R$  for B(PA) and B(Pp) laminates, regression equations of the second order were obtained (Tables 5 and 6).

Based on these, response areas were determined (Figure 3), reflecting the influence of changeable factors, i.e. adhesive mass PA, direction of layer arrangement in package  $D_1$  and cutting out direction of samples  $D_c$  on the flexural stiffness  $G$  of B(PA) and B(Pp) laminates before and after maintenance procedures  $M_{pr}$ .



**Figure 2.** Various placements of layers in the package: 1 – upper fabric, 2 – textile insert, → direction of the warp.

While analysing the graphs presented in Figure 3 (see page 112), which indicate the relationship between B laminate flexural stiffness and PA adhesive mass (12 - 20) as well as the direction of layer arrangement  $D_1$  of the samples before and after maintenance treatment  $M_{pr}$ , the significant impact of each of the factors examined is observed.

An increase in the deposited thermo-plastic polymer PA from 12 g/m<sup>2</sup> to 20 g/m<sup>2</sup> entailed/induced an increase in the stiffness index G by 18 to 41% before maintenance treatment and by 5 - 53% after maintenance treatment. The above-mentioned examinations also indicated the dominant influence of the layer arrangement and direction in which the sample is cut out in the laminates examined. The highest values of G index before (93 - 185 μN·m) and after (50 - 110 μN·m) maintenance treatment for B(PA) laminate were obtained at the sample cutting out direction of  $D_c = 0^\circ$ , which proves the dominant impact of the surface fabric warp (stiffness the surface material for  $D_c = 0, 45, 90^\circ$  averaged 75, 23, 14 μN·m). On the other hand, the lowest values of G index before (33 - 48 μN·m) and after (20 - 31 μN·m) treatment were determined for the weft direction in which the sample is cut out  $D_c = 90^\circ$ , in particular for packages of layer arrangement direction 0 - 45° and 0 - 90°.

The graph shapes obtained for B(Pp) and B(PA) laminates are similar and the ranges obtained of G values for the laminates examined were also very similar. Consequently, the highest and the lowest G values are in the same ranges as for B(PA) laminate.

The examinations carried out also indicate the big influence of maintenance treatment employing dry cleaning, which is proved by significantly lower G values – by 20 - 50% in the case of B(PA) laminate and by 20% for B(Pp) laminate – depending on the direction of layer arrangement  $D_1$  and direction of sample cutting out  $D_c$ . This means that the maintenance treatment  $M_{pr}$  carried out caused unfavourable changes in the input properties of the laminate inducing lower stiffness index values similar to those of the surface layer stiffness (75 μN·m), and in some cases even below. This indicator that the specific shape stability obtained, resulting from adhesive bonding, was disturbed after the maintenance procedures. The most consequential reduction

**Table 3.** Range of changeability factors for B(PA)\* laminate.

Factor	Code	Central value	Changeability unit	Measurement unit
Adhesive mass m	X <sub>1</sub>	16	4	g/m <sup>2</sup>
Direction of layer arrangement D <sub>1</sub>	X <sub>2</sub>	45	45	°
Cutting out direction D <sub>c</sub>	X <sub>3</sub>	45	45	°

**Table 4.** Range of changeability factors for B(Pp)\* laminate; \*Symbols B(PA) and B(Pp) designate laminates created by adhesive joining of surface fabric B with clothing inlayers PA and Pp, respectively.

Factor	Code	Central value	Changeability unit	Measurement unit
Direction of layer arrangement D <sub>1</sub>	X <sub>1</sub>	45	45	°
Cutting out direction D <sub>c</sub>	X <sub>2</sub>	45	45	°

**Table 5.** Influence of maintenance procedures  $M_{pr}$  on selected mechanical features of the laminates analysed B(PA), depending on the mass of glue m [g/m<sup>2</sup>], direction of layers in package  $D_1$  in ° and the direction of cutting the swath  $D_c$  in °.

Analyzed feature	Regression equations for laminate B(PA)		R
	$M_{pr} - 0$		
Flexural stiffness G <sub>0</sub>	$G_0 = 68.2398 + 1.2250X_1 + 0.7394X_2 - 1.0038X_3 + 0.0733X_1^2 - 0.0033X_1X_2 - 0.0010X_2^2 - 0.0179X_1X_3 - 0.0108X_2X_3 + 0.0092X_3^2$		0.98
$M_{pr} - 5$			
Flexural stiffness G <sub>5</sub>	$G_5 = 31.2315 + 1.4417X_1 + 0.4774X_2 - 0.2499X_3 - 0.0111X_1^2 + 0.0094X_1X_2 - 0.00033X_2^2 - 0.0048X_1X_3 - 0.0100X_2X_3 + 0.0033X_3^2$		0.97

**Table 6.** Influence of maintenance procedures  $M_{pr}$  on selected mechanical features of the laminate analysed B(Pp), depending on the direction of layers in package  $D_1$  in ° and the direction of cutting the swath  $D_c$  in °.

Analyzed feature	Regression equations for laminate B(PA)		R
	$M_{pr} - 0$		
Flexural stiffness G <sub>0</sub>	$G_0 = 111.9750 + 0.3987X_1 - 1.0546X_2 + 0.0020X_1^2 - 0.01181X_1X_2 + 0.0069X_2^2$		0.99
$M_{pr} - 5$			
Flexural stiffness G <sub>5</sub>	$G_5 = 85.8055 + 0.3037X_1 - 0.6581X_2 + 0.00158X_1^2 - 0.0085X_1X_2 + 0.0035X_2^2$		0.99

of the G index for B(PA) laminate was related to the samples cut out in the warp direction at arrangement directions 0 - 0° and 0 - 45°. It might be due to the partial washing out of the surface fabric finish in the process of dry cleaning, which was confirmed by the lower mass of the surface fabric (by 4 - 6%).

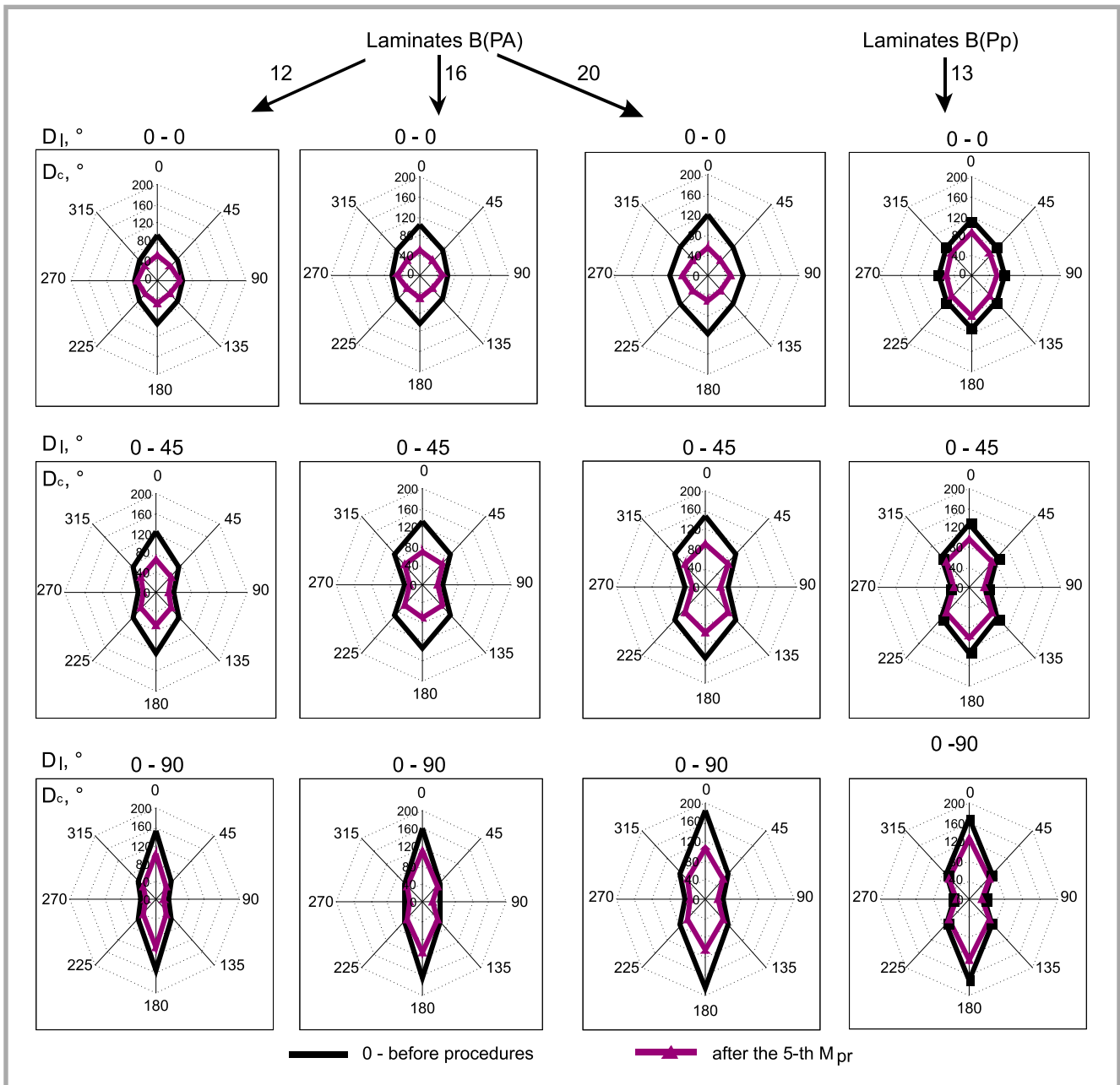
It was also noted that despite the lower amount of adhesive, the B(Pp-13) laminate is characterised by higher stiffness than B(PA-16) laminate. An additional advantage is the fact that among all the examined variants, the least changes in stiffness value following maintenance treatment were noted for the laminate with double adhesive point.

## Conclusions

The results of the experiments carried out in the course of this study take the form of the following conclusions:

1. The mathematical models of the adhesive lamination obtained effect on the flexural stiffness value of laminates allows us to predict changes in laminate properties, depending on the mass of deposited adhesives, layer arrangement direction and direction in which the sample is cut out.
2. The best results for the flexural rigidity values of the laminates examined were obtained for the cutting out direction accomplished along the warp.
3. The effect of maintenance procedures including dry cleaning and ironing on the shape durability of clothing laminates was determined. The examinations carried out indicated that the above-mentioned maintenance treatment induces a reduction in flexural rigidity. It may be caused by partial washing out of the surface fabric finish.





**Figure 3.** Effect of maintenance procedures  $M_{pr}$  on flexural stiffness index values  $G$  in  $\mu N^*m$  of B(PA) and B(Pp) laminates, depending on the adhesive mass  $m$  in  $g/m^2$ , layer arrangement direction  $D_1$  in  $^\circ$  and sample cutting out direction  $D_c$  in  $^\circ$ .

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