Investigation of Textile Bonded Seams

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The strength of textile bonded seams is analyzed. The bonding is based on utilization of thermoplastic properties of main materials and materials used for bonding. In order to get the bond, particular parameters have been selected, among them bonding temperature, pressure and duration. During the selection of parameters significant difficulties are encountered because the structure of bonded fabrics, their treatment and surface properties are very different. It was stated that the optimal parameters of film transfer are 160 °C and 10 sec and optimal parameters of layer bonding are 180 °C and 30 sec. In case of too low film transfer temperature the film soaks into the lower layer of specimen insufficiently, whereas in case of too high temperature it soaks overmuch.

Keywords: thermoplastic film, textile bond, peeling, parameters.

INTRODUCTION

Fabric bonding is a relatively new application for adhesives. The particular demands that a fabric bond must satisfy make the replacement of conventional thread stitching very difficult: adequate bond strength, resistance to washing and cleaning, no staining or discoloration, no spoiling of texture, maintain breathability, rapid setting [1].

The thermoplastic materials can be incorporated into the fabric or there is a wide range of films, tapes, nets and even coated threads that can be sandwiched between the layers of non-thermoplastic materials. Adhesives are widely used in textile industry for: bonding layers of materials together, bonding fibres together [2 – 4], application of protective layers (coated fabrics [5 – 7], carpet backing [8, 9]), application of decorative finishes [10].

Bonded seams are developed by BEMIS company for the textile industry [11]. It allows the elimination of sewing for many applications, including seams, hems, zippers, pockets and patches. Owing to the adhesive films designers may perfect the technology of garments and improve their construction. Sewfree bonds bring both aesthetic and economic benefits.

New design possibilities are opened up as a result of Sewfree's ability to permanently bond an almost unlimited range of materials. Bonded garment technology allows for a seamless look and feel. A bonded seam can be waterproof [12] and bonded garment typically weighs less than a sewn garment. For the articles bonding with thermoplastic film manufacturers can use flat fusing press. However ultrasonic [13, 14] and radio frequency welding can also be used.

The bond between substrate and adhesive depends on their chemical nature. If the substrate has an irregular surface, then the adhesive may enter the irregularities prior to hardening. This simple idea gives the mechanical interlocking theory, which contributes to adhesives bonds with porous materials such as textile. The chemical bonding theory of adhesion invokes the formation of covalent, ionic or hydrogen bonds [15]. Different technologies of pasting and welding are used for thermoplastic bonding of textile layers. One of them employ transfer coated products. This technology is comparable new and was developed firstly for knitted fabrics joining [16]. Due to this technology firstly the thermoplastic film is transferred from the base silicon paper to textile layer and during the second stage the main bonding of textile layers constructing seam is performed.

Quality of the joined layers depends on their bonding parameters such as temperature, pressure intensity and pressing time used during both bonding stages [16]. In order to obtain particular bond, correct parameters must be chosen. The melting point of thermoplastic film needs to be not too high, because it affects the dimensional stability, colour and handle of the fabric. Again, too low temperature can be the reason of the bond failure [10].

The aim of this work is to determine the influence of different bonding parameters to the strength of bonded seams, using fabrics of different structure parameters.

EXPERIMENTAL

Four commercial fabrics of different structure and fiber content were used in this experiment. Table 1 provides basic information about the tested materials [17, 18].

The textile specimens were cut in lengthwise direction. The dimensions of specimens were 80 mm × 25 mm. Two textile tapes were bonded together using BEMIS thermoplastic polyurethane film with base silicone paper. The dimensions of thermoplastic film specimens were 10 mm × 25 mm. The thickness of film layer was 0.09 μm. Due to the usage of silicon paper the specimen's bonding was performed with Stirovap press in two stages using different bonding conditions.

1 stage. Thermoplastic films were transferred from the base of silicone paper under fabric layer of specimens using 160 °C temperature and different pressing time: 10, 20 or 30 seconds.

2 stage. Lower fabric layer (L) of specimens which contains thermoplastic film and upper fabric layer of specimens (U) were bonded using 30 seconds pressing time and different temperature: 170, 180 or 190 °C.

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Table 1. The characteristics of investigated fabrics

Fabric	Fiber content	Density, dm^{-1}		Surface density, g/m^2	Thickness, at p = 0.19 MPa, mm [19]
		Weft /Course	Warp/Wale		
A (woven)	Cotton with silicone treatment	330	440	230	0.51
C (knitted)	Polyester	240	200	250	0.83
D* (laminate)	Polyester (woven) Polyester (knitted)	700 170	380 170	253	0.79
E (woven)	Cotton	150	330	320	0.79

Note: * – three layer laminate: polyurethane film between knitted and woven layers.

During both bonding stages the same pressure of 3.7 N/cm^2 was used The bonding conditions were chosen according to the properties of thermoplastic films and tested fabrics. The softening point of thermoplastic film is comparably low – only 72 °C, and heat resistance of tested fabrics from polyester and cotton fibres reaches 200 °C and more.

The pressing time of thermoplastic films and specimens was chosen considering the economic aspects.

Before the tests all specimens were kept at standard conditions of 65 % RH and 20 °C.

Textile bonded seams were investigated using two methods:

1. measuring the bonding strength,
2. analyzing photos of the scanning electron microscope (SEM) FEI Quanta 200 FEG.

The measurements of bonded seams strength were carried out on the „TINIUS OLSEN H10KT“ tension machine (Fig. 1) [20].

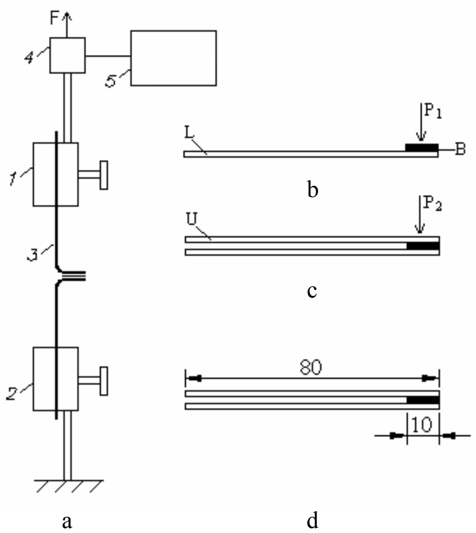


Fig. 1. The layout of „TINIUS OLSEN H10KT“ tension machine: 1 – upper grip, 2 – bottom grip, 3 – specimen, 4 – the sensor of force measurement, 5 – software equipment (a), adhesive film (B) transferring (b), bond of fabric layers (L and U) (c), parameters of specimen (d)

Usually 100 mm distance between grips is used for woven fabrics. Considering the higher extensibility of knitted fabrics, the 50 mm distance between upper (1) and bottom (2) grips was chosen. The speed of the upper grip was kept at 100 mm/min. The length of textile specimens was 80 mm and width – 25 mm. The length of adhesive film was 10 mm and width – 25 mm. Experimental data was received as a diagram (Fig. 2). The diagram of textile bonded seam strength was divided into three zones.

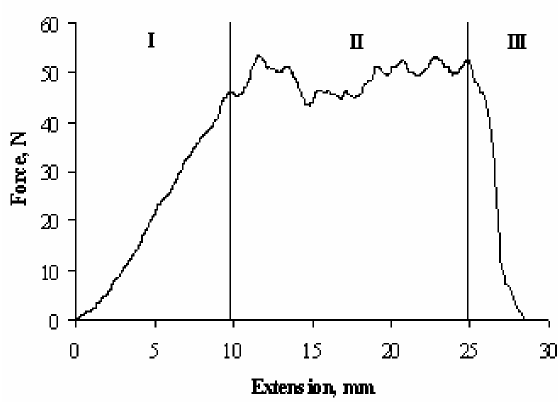


Fig. 2. Diagram of textile bonded seam strength: I – strain zone, II – peeling zone, III – end of peeling

In zone I specimen only strains, in zone II specimens' layer began to peel and peels and in zone III specimen brakes. For these reasons only zone II data is used for further investigation.

RESULTS AND DISCUSSIONS

The results of bonded seam strength are presented in Fig. 3. As seen the values of the strength of textile bonded seam ranged from 1.55 N to 62.71 N. The coefficient of variation of test results ranged from 0.3 % to 15.1 %.

As it can be seen in the diagrams, increasing thermoplastic film transferring time has no significant influence on the strength of cotton fabrics bonded seams (Fig. 3). The highest value of bonding strength of laminate D (62.71 N) was obtained by transferring thermoplastic film on layer L using 160 °C temperature and 20 sec pressing time and then bonding laminate layers L and U together at 190 °C temperature. The highest value of bonding strength of knitted fabric C (56.01 N) was obtained by transferring thermoplastic film on layer L using 160 °C temperature and 10 sec pressing time and then bonding laminate layers L and U together at 190 °C temperature. It was expected to get higher bond strength with the increase in bonding temperature [21]. The results of bonded seam strength of investigated fabrics confirmed these expectations. Bonded seam strength of laminate D increased by 9 N when bonding temperature increased

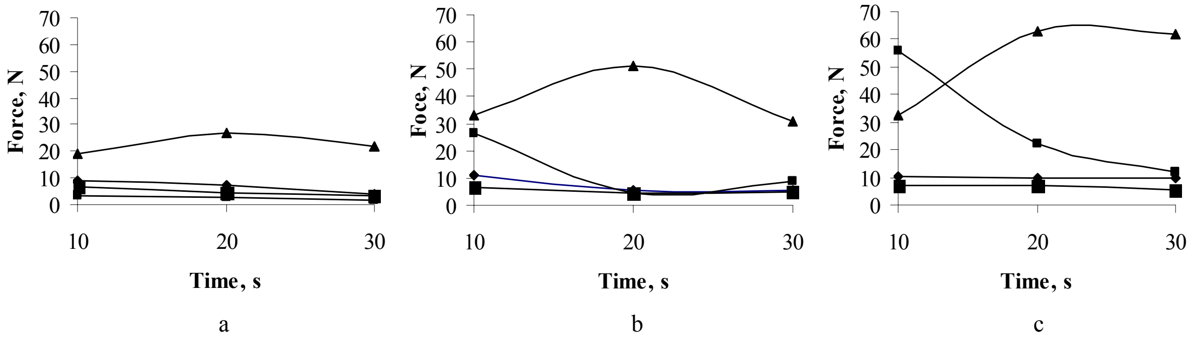


Fig. 3. Strength of textile bonded seams, when thermoplastic film transferring parameters were: 160 °C temperature and pressing time: 10, 20 and 30 seconds and bonding parameters were: 170 °C (a), 180 °C (b) or 190 °C (c) temperatures and 30 seconds: ♦ – fabric A, ■ – knitted fabric C, ▲ – laminate D, ■ – fabric E

from 170 °C to 180 °C and it increased by 30.82 N when temperature was increased to 190 °C. Bond strength increased for the knitted fabric C as well: with the increase of bonding temperature from 170 °C to 180 °C, bond strength increased by 7.17 N and with the increase from 180 °C to 190 °C – by 3.16 N. Meanwhile bond seam strength of cotton increased less, for example the bond strength of fabric E increased by 1.36 N when bonding temperature increased from 170 °C to 180 °C and it increased by 0.64 N when temperature was increased till 190 °C.

Investigation results of bonded seam strength show that the best parameters for thermoplastic film transferring are: 160 °C temperature and 10 sec pressing time. If transferring time is 20 or 30 seconds, the strength of bonded seam is lower (Fig. 3). Such situation occurs because in case of too low film transfer temperature the film soaks into the lower layer of specimen insufficiently, whereas in case of too high temperature it soaks overmuch. After the comparison of bonding strengths of investigated fabrics it can be stated that the highest values of bonding strength are obtained when film transferring time is 10 sec and bonding temperature is 180 °C: D (32.81 N), C (26.68 N), A (10.92 N) and E (6.4 N).

During the visual evaluation of specimens after peel test it was obvious that thermoplastic film remains on the L specimens' layer and there is no sign of it on U layer of A and E fabrics. Meanwhile a little peaces of it remain on U layers of specimens of knitted fabric C and laminate D. It is so because the bonds of these materials are better in comparison with materials A and E. In order to explain obtained strength values of the bond, the structure of bonded specimens was investigated using the scanning electron microscope (SEM).

After morphological tests of woven fabric E using SEM, it was determined that bond strength is low not only because of silicone treatment, but also because of its small bearing surface.

Threads between the streaks are not bonded with thermoplastic film 3 during transferring to L specimen layer 1 and during the U specimen layer 2 bonding (Fig. 4, a). While analyzing bonded seam of fabric A it can be observed that during transfer of the film it soaked only into U threads of L fabric of specimen (Fig. 4, b). U layer bonded to the L layer only in a few places. That is so because the fabric was treated with silicone. This is the main reason of low strength of the bond.

The highest values of bonding strength are obtained in case of laminate D. It is difficult to explain differences in bonding strength while film is transferred using different parameters: 160 °C 10, 20 or 30 sec and bonding U and L fabric layers using temperature of 180 °C and pressing time of 30 sec. In our opinion, the high strength of bonding is obtained because smooth weaved surfaces of specimens are bonding uniformly and it is hard to make a difference between U and L layers of specimens (Fig. 5, a).

In case of knitted fabric C the highest strength of the bond is obtained in case of film transfer at 160 °C temperature and pressing during 10 sec and subsequent bonding of layers of specimen at 180 °C temperature and pressing for 30 sec. If the duration of film transfer is increased the strength of the bond is decreased. The main

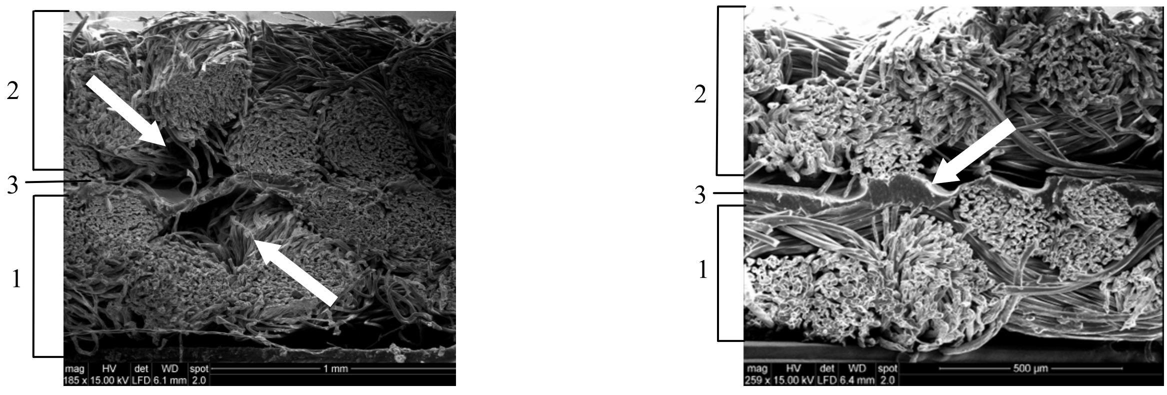
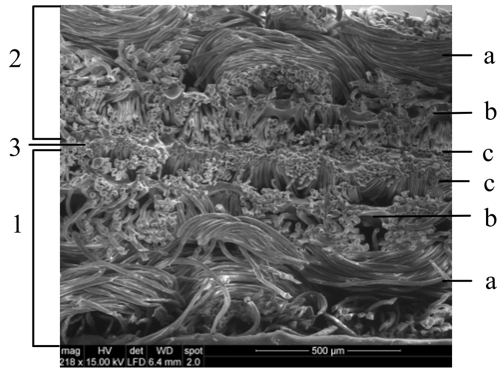
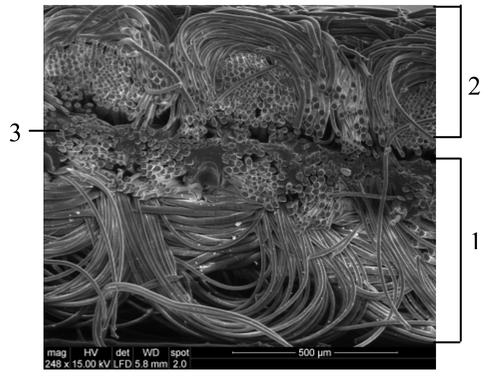


Fig. 4. The morphology of cotton E (a) and A (b): 1 – L specimens layer, 2 – U specimens layer, 3 – thermoplastic film



a



b

Fig. 5. The morphology of laminate D (a) bonded seam: 1 – L specimens layer: a1 – knitted layer, b1 – polyurethane film, c1 – woven layer; 2 – U specimens layer: a2 – knitted layer, b2 – polyurethane film, c2 – woven layer; 3 – thermoplastic film and polyester C (b) bonded seam: 1 – L specimens layer, 2 – U specimens layer, 3 – thermoplastic film

reason for it is that during transfer film soaks into the knitted fabric and only a small portion of the film bonds with U specimen (Fig. 5, b).

CONCLUSIONS

1. On the basis of the obtained results it can be stated that the quality of bond of fabrics depends on proper selection of parameters of two bonding stages: film transfer and layer bonding.
2. Optimal parameters of film transfer in case of investigated materials are 160 °C and 10 sec and optimal parameters of layer bonding in case of investigated materials are 180 °C and 30 sec.
3. The highest values of bonding strength under optimal bonding parameters are in the case of laminate D (32.81 N), the lowest in the case of cotton fabrics E and A (10.92 N, 6.4 N).
4. Bonding strength of investigated fabrics depends on its structure type, bearing surface and treatment.

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