International Joint Conference on Environmental and Light Industry Technologies
18-19 November 2010, Budapest, Hungary
Óbuda University

ANALYSIS OF FABRICS AND SEAMS IN AIRBAGS

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Abstract:

Airbag fabrics belong to the group of heavy synthetic fabrics. Due to relatively coarse synthetic multifilament warp and weft yarns and high density, the weaving of these fabrics is very demanding. Apart from that, joining parts of the airbag using sewn seams requires special sewing machines and automata. The impact of individual sewing parameters as thread tension and fineness, needle type and thickness, stitch type and length on the quality of the joint are of exceptional importance for passenger safety. This paper analyses the construction parameters of the fabrics used for different airbags. The types of sewn seams and stitch length will be investigated. The mechanical properties of seamed and seamless fabrics will be tested. Thread types and properties will be examined. Investigations of the airbag shape and size depending on the use will be investigated.

Keywords:

airbag, fabric, mechanical fabric properties, sewn seam, airbag sewing thread, shape of airbag

1 INTRODUCTION

Airbags are nowadays essential installation parts of each car because they reduce injuries to a passenger in the vehicle at the moment of an accident. They are made from fabrics of polyamide or polyester multifilament synthetic fibers with extremely high density and strength. As a result of the development of cars more effective and more numerous motor vehicle airbags are being developed. This requires increasing demands in making fabrics, cutting, sewing and joining in the most convenient form for an air bag [1-3]. The volume of the driver airbag in full size ranges from 60 to 65 liters of air or gas, while the passenger airbag has a volume of 150 liters. When the explosive charge of the airbag is activated, 2 bar pressure develops within the airbag. The system for the two-stage activation of the front airbags, which reduces the load in the event of an accident, affects the driver and the front passenger. This reduces the risk of breaking the sewn seams. Double-stitched seams are mostly used, because when one is damaged, the other one remains intact. Taking account of it, multilayered fabrics are used in the places exposed to the highest load of the airbag, and synthetic coatings on the fabric back. Sewing on special sewing automata where each sewn seam is stitched on the other automatic machine, which is fully adapted to the seam with the most optimal properties of the seam, guarantees maximum safety during airbag deployment.

2 WEAVING AND SEWING AIRBAGS

Airbag fabrics are manufactured exclusively from very strong multifilament synthetic yarns with a high tex number. Weaving machines are sturdy, the weft yarn is inserted mostly with rigid rapiers or projectiles and the shed is formed by means of tappets. The only weave type is plain weave that provides the best coverage and thus the lowest air permeability. To achieve the full air tightness of the airbag, the fabric is coated with synthetic coating on the inner side of the air bag. In the case of these fabrics attention should be paid to fabric faults and to places of warp and weft breakage as well as sparse stripes because they are potential places of air permeability in airbag deployment [2, 3].

Airbag safety also depends on the quality of joints. Cutting parts of airbags are mostly joined with sewn seams whereby chain stitch or lockstitch are used, depending on which part of the air bag is joined. An irregular or skipped stitch could be fatal in case of an accident. It is important to make a precise shape of the air bag according to the car shape and size. It is important to make a precise shape of the air bag according to the car shape and size. Likewise, the quality and strength of seams, which must withstand gas pressure and the impact of the body against the airbag, is also important. Sewn seams represent the weakest part of the air bag, and this is the reason why new sewing automata for sewing airbag seams have been developed. Joints are often made with double-stitched seams, because in case of breaking one seam the other one takes over the resistance to gas pressure at the moment of opening. In most cases these are chain stitch seams that impart elasticity. Furthermore, it is necessary to choose strong and elastic thread, stitch length and shape, type of needle and thread tension for each seam separately. In this case, special sewing machines and automata are used which have the possibility of stitching two or more layers of densely woven fabrics without any damage by using special sewing needles (Fig. 1) [4-8].

Figure 1 Airbag sewing done by Dürkopp Adler

1 EXPERIMENTAL PART

The experimental part has been performed on fabrics intended for the front airbags in motor vehicles (Figs. 2, 3). Selected fabrics are used for three different European middle class cars. The fabric for all airbags in one car is the same as well as coated parts in airbags for reinforcements (Figs. 1,$_{5}$, and 2,$_{3,4}$). Testing was performed on the fabric without the inner coating to improve air tightness. The basic parameters of fabrics for three types of passenger cars were examined (Table 1). Mechanical testing on the tensile tester was carried out in the warp and weft direction, with and without seam, and using the ball burst testing method. Sewing threads were tested, and stitches were analyzed (Table 2). Breaking force, breaking elongation and ball burst resistance of the airbag on an Apparecchi Branca S tensile strength tester. Tests of tensile force and elongation at break of fabrics was carried out in accordance with ISO 5081, and bursting strength in accordance with HRN EN ISO 13938.

The breaking force and breaking elongation of the sewing thread were tested with Statimat M tensile tester made by Textechno in accordance with ISO 2062. Mesdan Twist Tester was used to test thread twist level. Thread fineness was tested with the method of winding 50 x 3 m on the reel and of weighing on the electronic analytical scales Tehtnica Model 2615. The SDL Air Permeability Tester was used to measure the permeability of airbag fabrics to air in accordance with EN ISO 9237.

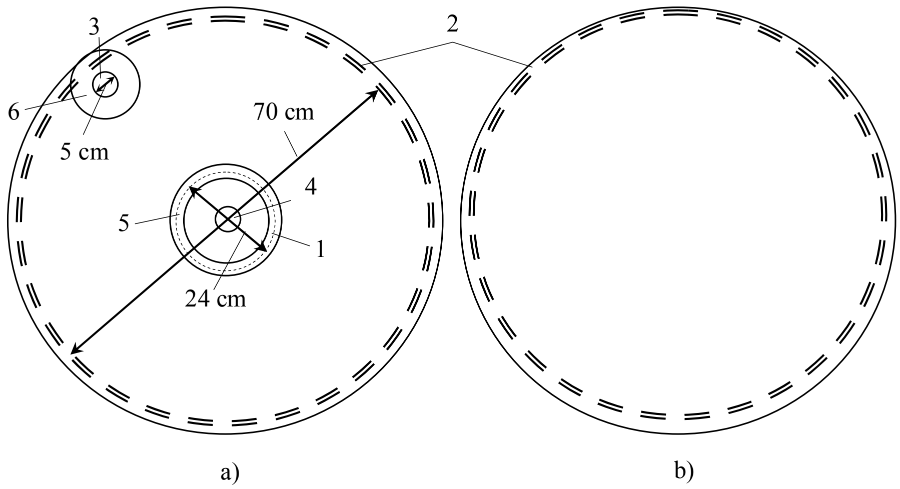

Figure 2: Driver front airbag

a) Front part of the airbag, b) Rear part of the airbag

1 - lock stitch, stitch length 3 mm, 2 - two sewn seams, chain stitch, stitch length 4 mm, 3 - hole in the airbag opened in case of air pressure, 4 - part of the airbag for reinforcement and air hole, 5 - three wreath-shaped fabric layers stitched on the back of the airbag, 6 - Layer of the artificial leather affixed to the fabric back side.

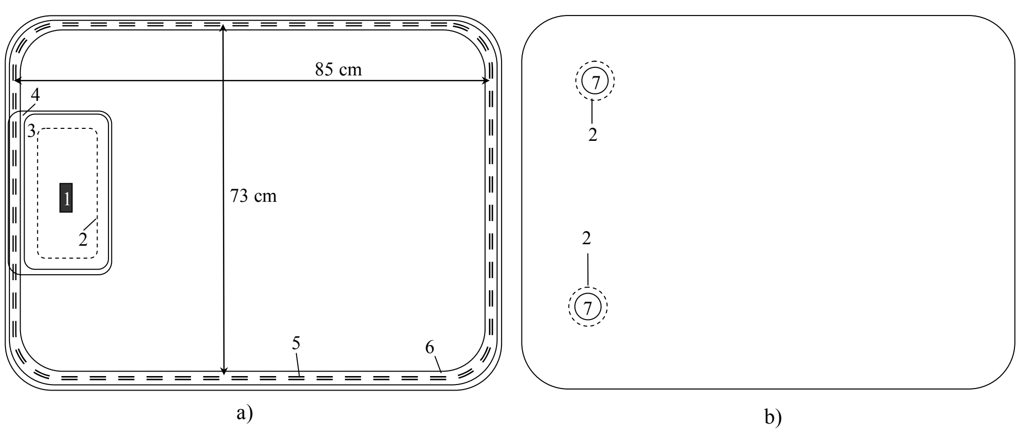

Figure 3: Rear passenger airbag

a) Front part of the airbag, b) Rear part of the airbag

1- part of the airbag for reinforcement and air hole, 2 - lockstitch, stitch length 3 mm, 3 - sewn on outer fabric layer, 4 - sewn on inner fabric layer, 5 two sewn seams, chain stitch, stitch length 3 mm, 6 sewn on fabric in tape form, 7 - holes on the rear side of the airbag which open under air pressure

Table 1: Basic parameters of airbag fabrics

	Basic parameters of fabrics and threads		Sample I	Sample II	Sample III
Fabric	Fabric density (threads/1 cm)	Warp	18	20	21
		Weft	18	18	18
	Yarn count (tex)	Warp	50	50	50
		Weft	50	50	50
	Mass per unit area (g/m^2)		269.78	288.01	292.3
	Fabric thickness (mm)		0.28	0.31	0.33
	Raw material composition		Polyester multifilament		
	Fabric weave		Plain weave		
Thread	Thread for chain stitch (Fig. 2.$_2$. Fig. 3.$_5$ – outside seam)	Breaking force (N)	123.86	176.55	172.02
		Elongation at break (%)	4.94	6.72	5.80
		Yarn count (tex)	123	138	130
		Twist level (twists/m)	154	138	184
		Raw material composition	Polyester multifilament		
	Thread for chain stitch (Fig. 2.$_2$. Fig. 3.$_5$ – inside seam)	Breaking force (N)	60.29	176.55	52.78
		Elongation at break (%)	10.31	6.72	8.20
		Yarn count (tex)	25×3	42×3	20×3
		Twist level (twists/m)	434	138	441
		Raw material composition	Polyester spun		
	Thread for lock stitch (Fig. 2.$_1$. Fig. 3.$_2$)	Breaking force (N)	45.70	51.44	42.93
		Elongation at break (%)	7.75	6.44	7.31
		Yarn count (tex)	25×2	25×2	22×2
		Twist level (twists/m)	360	381	352
		Raw material composition	Polyester spun		

Table 2: Values obtained by the tensile strength tester

Parameters tested on the fabric				F (N)	S (N)	CV (%)	ε (%)	S (%)	CV (%)
Braking force and elongation at break of the fabric	Sample I	Seamless	Warp	1850	100.3	5.4	27.5	1,8	6,5
			Weft	1352	83.2	6.2	22.4	1,9	8,5
		Seamed	Warp	1150	171.4	14.9	42.1	3,5	8,3
			Weft	1100	122.4	11.1	41.1	2,7	15,2
	Sample II	Seamless	Warp	1943	114.6	5.9	27.3	1,4	5,1
			Weft	1422	118.0	8.3	20.5	1,4	6,8
		Seamed	Warp	1229	127.9	10.4	33	3,2	9,7
			Weft	1187	142.0	12.0	30.2	3,6	11,9
	Sample III	Seamless	Warp	1982	93.5	4.7	29.1	2	6,9
			Weft	1483	92.7	6.3	25	3,5	14
		Seamed	Warp	1461	75.5	5.2	30.2	2,5	8,3
			Weft	1286	131.0	10.2	29.1	2	6,9
Breaking force and bursting strength of the fabric		Sample I		1150	52.6	4.6	21.4	2.8	13.0
		Sample II		1525	51.0	3.3	27.9	2.9	10.4
		Sample III		1559	74.8	4.8	28.4	3.0	10.6
Air permeability		Sample I		P= 1.480 (mm/s)					
		Sample II		P= 1.401 (mm/s)					
		Sample III		P= 1.390 (mm/s)					

F – breaking force (N), ε - elongation at break (%), S – standard deviation, CV – coefficient of variation, P – air permeability (mm/s)

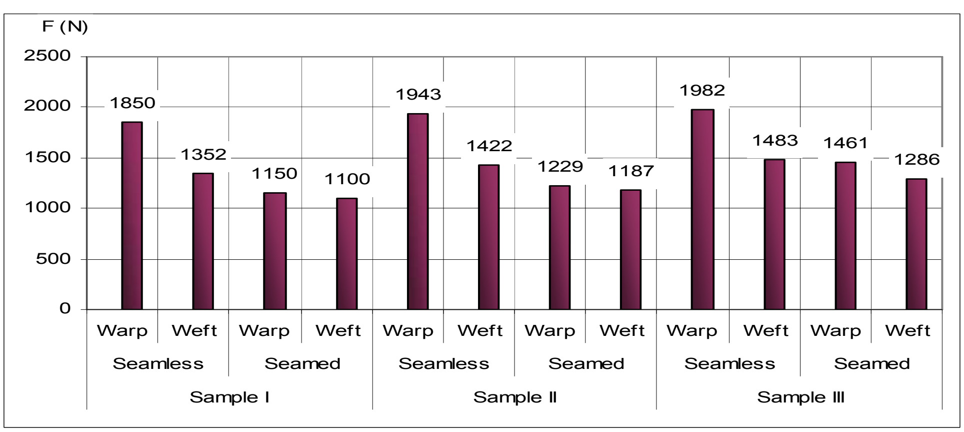

Figure 4: Fabric breaking forces

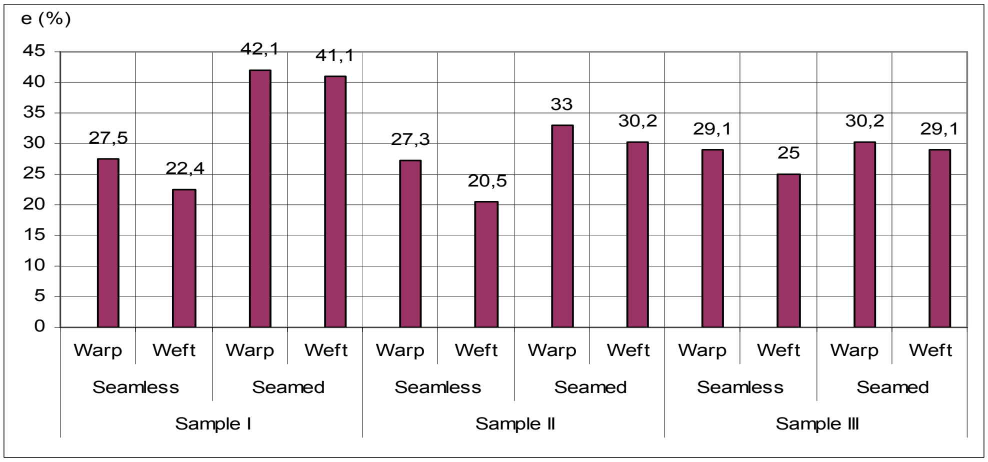

Figure 5: Fabric elongation at break

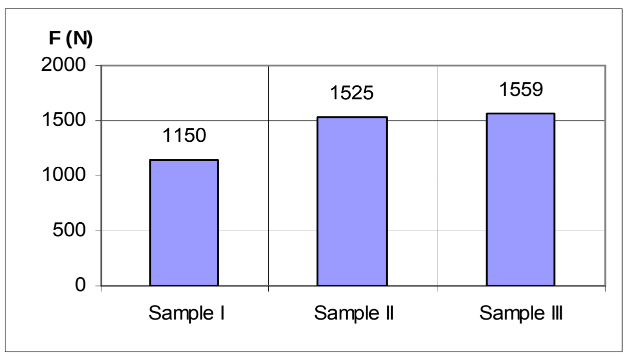

Figure 6: Bursting strength of the fabric

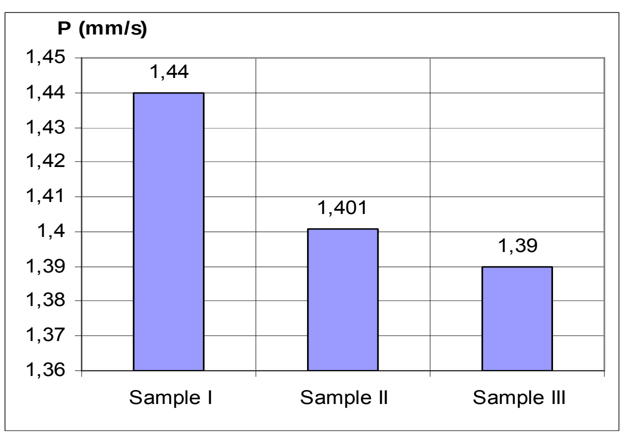

Figure 7: Air permeability of airbag fabrics

4 DISCUSSION

According to the results obtained (Tables 1, 2 and Figs. 4-7) the following can be said:

Fabric density in the warp direction is different, sample I has the lowest (18 threads/cm), while sample III has the highest density (21 threads/cm). Density in the weft direction is the same, amounting to 18 threads/cm. Yarn count in the warp and weft direction is equal for all the samples (50 tex). Mass per unit area is the lowest for sample I (269.78 g/m^2), and the highest for sample III (292,3 g/m^2). Fabric thickness follows changes in the values of mass per unit area, amounting to = 0.28 mm for sample I and to 0.33 mm for sample III. Raw material composition of the warp and weft for all three samples is multifilament polyester. The fabrics are woven in plain weave. The thread used for stitching edge parts of air bags, i.e. the seam that is closest to the edge of the fabric, is the strongest. Breaking force was 123.86 N for sample I and176.55 N for sample II.

Average breaking force of seamless airbag fabrics in the warp direction ranged from 1850 N (sample I) to 1982 N (sample III), and it was slightly higher than in the weft direction, ranging from 1352 N (sample I) to 1483 N (sample III), (Table 2, Fig. 4). Average breaking force of seamed airbag fabrics in the warp direction was lower in comparison to the seamless samples, and it ranged from 1150 N (sample I) to 1461 N (sample III). Breaking force of the seamed fabric in the weft direction ranged from 1100 N (sample I) to 1286 N (sample III). Considering breaking forces one can say that they were higher in the warp direction compared to the weft direction and that they were higher for the seamless samples compared to the seamed samples.

Average elongation at break in the warp direction for the seamless samples ranged form 27.3% (sample II) to 29.1% (sample III) (Table 2, Fig. 5). Elongation at break in the weft direction was lower for all the samples in relation to the warp direction, ranging from 20.5% (sample II) to 25.0% (sample III). Average elongation at break in the warp direction for the seamed samples ranged from 30.2% (sample III) to 42.1% (sample I). Elongation at break in the weft direction for the seamed samples was lower for the entire sample in relation to the warp direction, ranging from 29.1% (sample III) to 41.1% (sample I).

The test results for the airbag fabrics in the ball burst test ranged from 1150 N (sample I) to 1559 N (sample III) (Table 2, Fig. 6). Elongation at break was lower for lower breaking forces and vice verca, ranging from 21.4% (sample I) to 28.4% (sample III).

Air permeability was tested on the airbag fabrics (Tab. 2, Fig. 7). According to the results obtained it is observable that a denser fabric in the warp direction and a higher mass per unit area and thickness (sample III) has a slightly lower air permeability (1.390 mm/s) compared to sample I (1.480 mm/s).

5 CONCLUSION

According to the results obtained the following can be concluded: Airbag fabrics are very important for the safety of passengers in motor vehicles. These fabrics belong to the group of technical fabrics that are manufactured for a targeted application, requiring special machines in the production process. The specificity of these fabrics and extreme values of some parameters also include them into fabrics with the most demanding manufacturing process from raw material to finished product. They are made from synthetic multifilaments with an extremely large tex fineness with a relatively high density of warp and weft. Air permeability must be at a very low level, which is achieved by weaving and often synthetic coating on the back side of the fabric. Each warp or weft breakage in the fabric can cause fatal consequences, as insufficiently inflated air bag or premature deflation of gas until the gas poisoning from the air bag. In addition to the properties of airbag fabrics, the quality of the joints is also important. Joining the edges of air bags is usually performed with two chain-stitch seams. The first seam is weaker, which most commonly breaks at the time of airbag deployment, while the other is several times stronger, reaching fabric strength as well as complete safety. Sewing threads are mostly of a synthetic origin, and their strength depends on the requirements of the seam. An additional strength of the seam is achieved with fabric inserts on the edge seams, the holes and fixing points of the airbag to the parts of the vehicle. Due to very strict requirements on seam quality, sewing seams is carried out on sewing machines where each seam requires a special sewing automatic machine with special conditions. Considering different types of airbag fabrics, different sewing conditions and forms of airbags, it is important to find optimal parameters of the air bag to ensure the safety of passengers in a particular motor vehicle.

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The results presented in the paper resulted from the scientific program (Anthropometric Measurements and Adaptation of Garment Size System, code: 117-1171879-1887 and Advanced Technical Textiles and Processes, code: 117-0000000-1376) conducted with the support of the Ministry of Science, Education and Sports of the Republic of Croatia and bilateral project between University of Zagreb, Faculty of Textile Technology, Department of Clothing Technology and Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Polymer Engineering.

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