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ANALYSIS OF ARTIFICIAL LEATHER WITH TEXTILE FABRIC ON THE BACKSIDE

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ABSTRACT

The fundamental characteristics of a textile fabric intended for the vehicle interior is presented. Chemical and physical-mechanical properties of artificial leather with bonded textile fabric on the back side are analyzed. The most important parameters for leather durability are: breaking force and elongation-at-break, and these properties will be tested in different circular directions. Likewise, chemical properties of artificial leather and basic construction parameters of the textile fabric are investigated. When using artificial leather, physical-mechanical properties of artificial leather as well as the quality of the seams are most important. In addition to the results obtained, physical-mechanical properties and aesthetic evaluation of the joined places will be compared.

Keywords: Artificial leather, Textile fabric on the back side, Joined place strength, Seam strength, Physical-mechanical properties

Introduction

In addition to ergonomically designed car seats for keeping the body in a correct sitting position, it is important that the passenger feels no bodily fatigue due to sitting discomfort. Pleasant contact between the body and seat depends on the upholstered fabric that may be composed of a nonwoven, woven or knitted fabric and artificial leather (Figure 1). Artificial leather is a composite fabric which is mechanically and chemically finished to it a substitute for leather in fields such as upholstery, clothing and other uses where a leather-like finish is required but the actual material is cost-prohibitive or unsuitable. Artificial leather is marketed under many brands, including "leatherette," "faux leather," "patent leather," "Naugahyde" and "pleather". The term pleather (plastic leather) is a slang term for synthetic leather made out of plastic, a portmanteau of plastic and leather, the term can be either descriptive, or derogatory, depending upon the user (the derogatory use implies use as a substitute for genuine animal hide leather to cut costs). Pleather is often used as an inexpensive substitute for leather. Pleather may also be preferred because it is lighter than leather. Others choose to wear synthetic leather as an alternative to real leather citing reasons of animal cruelty. Pleather, being made of plastic, will not decompose as quickly. Not all pleathers are the same. Polyurethane is washable, can be dry-cleaned and allows some air to flow through the garment. PVC pleather in contrast does not "breathe" and is difficult to clean. PVC cannot be dry-

cleaned because the cleaning solvents can make the PVC unbearably stiff.

The nonwoven material lies in the interior of the seat and is used for lining solid metal, wooden or plastic car components [1, 2]. The exterior fabric which contacts the body should also have good aesthetics and good strength, toughness and abrasion resistance for the lifetime of the car. The fabric should be flame retardant, resistant to the sun's ultraviolet rays, and have a stain-resistant finish. Artificial leather possesses almost all properties expected of car seat upholstery. Artificial leather has all the attributes of natural leather, plus the added advantage that additional properties may be engineered into the fabric. First of all stability of the upholstery fabric can be improved by laminating woven or knitted fabrics, which is obtained by thermal joining. Thermal joining of the woven or knitted fabric and polyurethane foam to the back side of the artificial leather is carried out by coating a thin adhesive film which dries under high temperature and sticks the surfaces together tightly. The woven fabric imparts higher stability and strength to the artificial leather, whereas the knitted fabric imparts higher elasticity. Since the method of manufacturing artificial leather with textile fabric on the back side in being increasingly used, not only in motor vehicles, but also for many other purposes, this focus of this paper is just on the surface material.

Figure 1. Car seat upholstered with artificial leather

Manufacture of the fabric for the back side of artificial leather

The use of woven and knitted fabrics on the backside of the artificial leather will be discussed in greater detail below. To sew the different materials with synthetic leather, it is recommended that special sewing machines are used which can sew two or three layers of a tight-woven fabric without damaging the threads (Figure 2). A special sewing needle is also recommended. A sewing machine using a serv 7 sewing needle as made by the Schmetz company is used for sewing.

The fabric used for the back of artificial leather is a cotton fabric. The yarn is warped on the warping machine, afterwards sized and woven in relatively low warp and weft density. Air jet weaving machines are used for weaving in plain weave. After weaving the fabric is inspected, and faults, remaining threads and fly lint are removed, but in most cases it is not chemically treated. Fabric heat setting is carried out in the process of artificial leather manufacture. Besides woven fabric, warp knitted fabric is used, predominantly for artificial leather in articles of clothing. Artificial leather supplemented with woven or knitted fabric gains strength, durability and elasticity. Between artificial leather and woven or knitted fabric, polyurethane sponge is bonded by thermal joining, to add softness and flexibility to the upholstery fabric [3-5].

When cutting the artificial leather with woven fabric on the front side or knitted fabric on the back side and when spreading the cutting parts it is a rule that cutting parts are spread in the length direction or in the warp direction. This is the reason why the durability and stability of seat covers will extend over a longer period of time.

The technological process of sewing car seat covers can be divided into two groups: sewing universal car seat covers (for small, medium-sized and large automobiles) and customized sewing of car seat covers. The

creation of the plan of the technological process of sewing universal seat covers includes three operations:

1. Joining the back part of the seat cover with sitting part
2. Sewing the elastic band on the side parts of the car seat cover
3. Joining the side parts with the sitting section and the front section of the seat cover.

Figure 2. A special high-speed Pfaff 1427 sewing machine

Experimental

Artificial leather with a 1-2 mm thick polyurethane sponge and woven fabric (samples I and II) and artificial leather with a 1-2 mm thick polyurethane sponge and knitted fabric (samples III and IV) were used for experimentation. The artificial leather with sponge and woven fabric or sponge and knitted fabric is intended for upholstering the car interior design including car seats and was tested accordingly. The sewing thread is a filament of a count of 25x3 tex made of 100% polyester with 355 turns/m and Z twists. A special Pfaff 1427 high-speed sewing machine was used for sewing.

Breaking force of the sewing thread, tested on a Statimat M tensile tester made by Textechno in accordance with the ISO 2062 standard, is 62.58 N. Sewing thread twist level with 355 turns/m was tested on a Mesdan Twist tester. Sewing thread fineness is 25x3 tex, and was tested by winding 50x3 m on to a reel and by weighing on the electronic analytical balance, Tehtnica, type 2615. An Apparecchi Branca S tensile tester was used to test breaking force and elongation-at-break, and they were tested in accordance with ASTM D 1682 standard, and measurement for bursting strength with a ball burst strength tester was made in accordance with ASTM D 3787.

Table 1. Basic parameters of artificial leathers with polyurethane foam and woven/knitted fabric on the back side - all components are adhesive-bonded under the drying temperature

Parameters tested		Artificial leather with woven fabric on the back side		Artificial leather with knitted fabric on the back side	
		Sample I	Sample II	Sample III	Sample IV
Woven fabric density (threads/10	Warp	140.0	125.0	-	-
	Weft	100.0	100.0		
Yarn count (tex)	Warp	30		20×2	20×2
	Weft	30			
Surface mass (artificial leather with polyurethane foam and woven / knitted fabric (g/m^2))		80.4	78.8	80.7	79.9
Thickness without load (artificial leather with polyurethane foam and woven / knitted fabric (mm))		3.31	3.22	3.31	3.22
Raw material composition		Artificial leather, polyurethane sponge, cotton woven fabric		Artificial leather, polyurethane sponge,	
Fabric weave and knitted fabric structure		Plain weave		Warp knitted fabric	

Table 2. Breaking forces and elongation-at-break of artificial leather with polyurethane foam and woven/knitted fabric

Description of artificial leather & components		Cutting angle of the samples (Fig. 3, 4)	F (N)	S (N)	CV (%)	ε (%)	S (%)	CV (%)
Sample I	Seamless samples cut in several directions	Weft (0^0, 360^0 and 180^0)	549.0	73.6	13.4	18.6	3.3	17.6
		30^0 and 210^0	224.0	63.6	28.4	25.7	4.2	16.2
		60^0 and 240^0	411.0	60.4	14.7	20.7	4.7	22.5
		Warp (90^0 and 270^0)	677.0	71.1	10.5	16.9	2.3	13.5
		120^0 and 300^0	423.0	66.4	15.7	21.3	4.1	19.4
		150^0 and 330^0	211.0	52.5	24.9	23.4	3.4	14.4
	Sample seamed in weft direction		582.0	91.4	15.7	16.3	2.6	15.9
Sample II	Seamless samples cut in several directions	Weft (0^0, 360^0 and 180^0)	623.0	121.5	19.5	22.4	3.7	16.3
		30^0 and 210^0	314.0	64.1	20.4	23.8	4.5	18.9
		60^0 and 240^0	433.0	79.7	18.4	20.4	3.6	17.5
		Warp (90^0 and 270^0)	714.0	82.1	11.5	16.6	2.4	14.7
		120^0 and 300^0	450.0	67.5	15.0	22.5	4.2	18.5
		150^0 and 330^0	302.0	68.0	22.5	23.1	4.8	20.6
	Sample seamed in weft direction		577.0	110.2	19.1	14.4	2.5	17.4
Sample III	Seamless samples cut in several directions	Cross (0^0, 360^0 and 180^0)	581.0	77.9	13.4	19.4	3.4	17.6
		30^0 and 210^0	395.0	108.2	27.4	20.0	4.0	20.2
		60^0 and 240^0	444.0	111.4	25.1	17.2	2.8	16.5
		Longitudinal (90^0 and 270^0)	606.0	113.3	18.7	17.7	2.8	16.0
		120^0 and 300^0	478.0	112.8	23.6	20.4	3.9	19.0

		150^0 and 330^0	377.0	76.9	20.4	22.0	4.9	22.2
	Sample seamed in cross direction		471.0	56.0	11.9	14.9	2.7	18.3
Sample IV	Seamless samples cut in several directions	Cross (0^0, 360^0 and 180^0)	522.0	76.7	14.7	18.1	3.6	19.9
		30^0 and 210^0	475.0	77.9	16.4	22.2	4.4	20.0
		60^0 and 240^0	391.0	54.3	13.9	18.7	3.2	16.9
		Longitudinal (90^0 and 270^0)	578.0	72.3	12.5	14.9	1.7	11.1
		120^0 and 300^0	404.0	58.2	14.4	17.9	3.0	16.7
		150^0 and 330^0	466.0	48.9	10.5	21.5	4.3	19.9
	Sample seamed in cross direction		478.0	67.9	14.2	9.5	1.9	20.5

Samples I, II - Artificial leather with polyurethane foam and woven fabric on the back side, samples III and IV - Artificial leather with polyurethane foam and knitted fabric on the back side; F - Breaking force (N), ε- Elongation at break (%), S - Standard deviation, CV - Coefficient of variation

Table 3. Bursting strength and elongation-at-break during the ball burst test of the artificial leather with polyurethane foam and woven/knitted fabric – all components are adhesive-bonded under the drying temperature

Sample	F (N/m^2)	S	CV	ε (%)	S	CV
I	2186	146.5	6.7	24.5	2.1	8.4
II	2249	188.9	8.4	27.1	2.9	10.6
III	2004	252.0	10.5	30.3	3.4	11.2
IV	2110	286.4	12.4	33.1	4.9	14.7

F – Bursting force (N / m^2) - tested surface of the sample: $(d^2 \times r^2) / 4 = 19.625 \times 10^{-4}$ m^2; according to ASTM D 3787,
ε - Elongation at break (%), S - Standard deviation, CV - Coefficient of variation

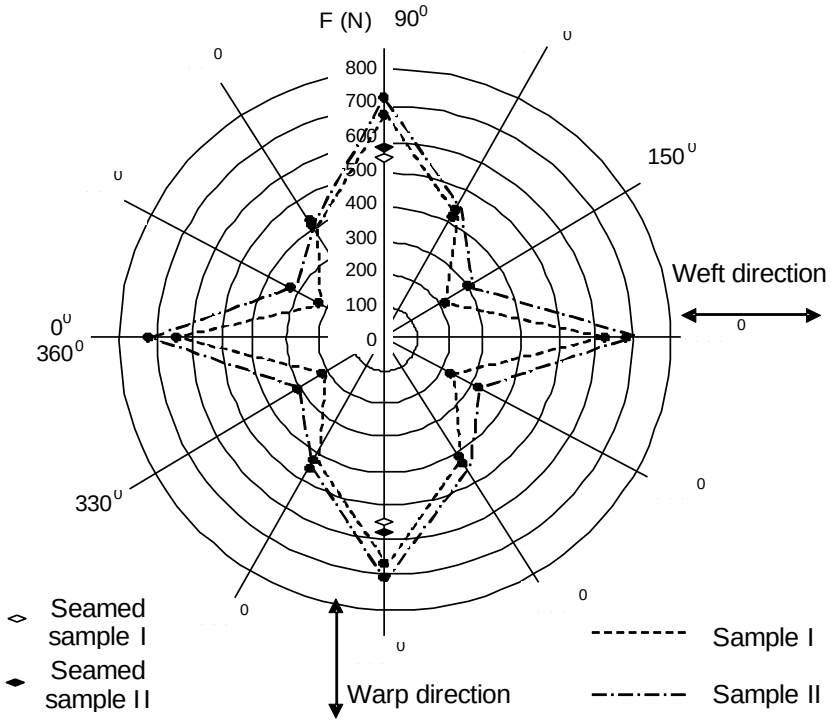

Figure 3. Breaking force of the artificial leather with polyurethane foam and lined woven fabric; seamless samples cut in different directions, and sample seamed in weft direction

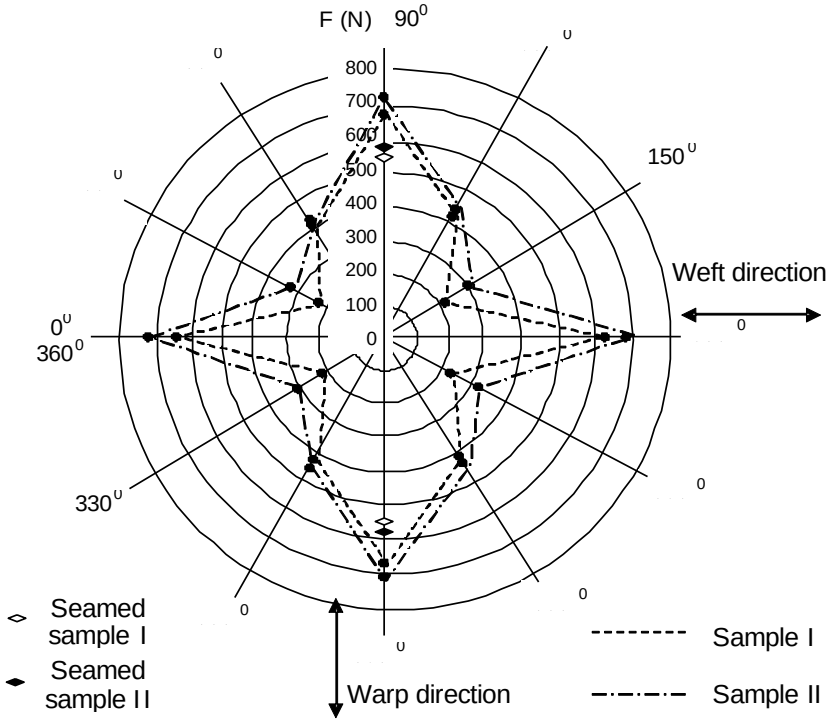

Figure 4. Breaking force of the artificial leather with polyurethane foam and lined knitted fabric; seamless samples cut in different directions, and sample seamed in cross direction

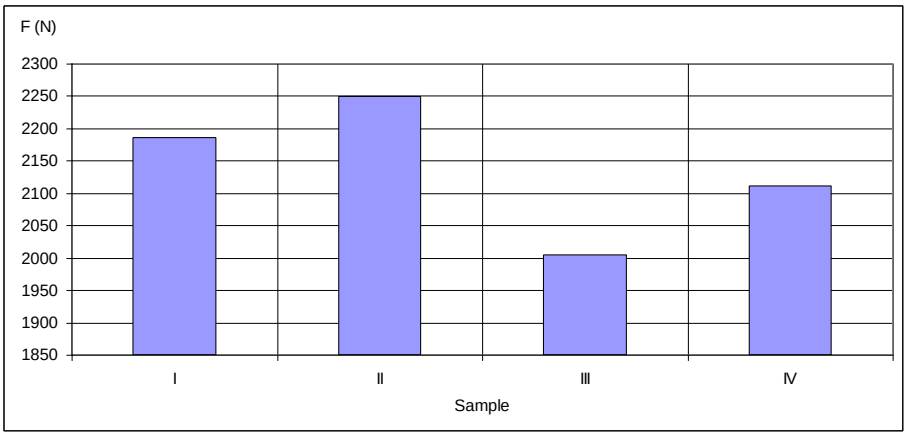

Figure 5. Breaking force during the ball burst test of the artificial leather with polyurethane foam and woven / knitted fabric

Discussion

The samples of the artificial leather with woven fabric on the back side (samples I and II) and the samples with knitted fabric on the back side (samples III and IV) differ in average breaking force and average elongation-at-break (Tab. 2, Figs. 3 and 4). The fabric samples were taken in 6 different directions at a distance of 30º.

The samples of the artificial leather with woven fabric on the back side have the highest breaking force in the warp direction ranging from 677 N (sample I) to 714 N (sample II), and the lowest at angles of 150º and 330º (211 N – sample I and 302 N – sample II), and the woven fabric was the most sensitive (Tab. 2, Figure 5). At angles of 30º and 210º the warp and weft occupy the same position, breaking forces are slightly higher than the previous ones, ranging from 224 N (sample I) to 314 N (sample II). Breaking force measured in different directions of the woven fabric differs in sample I from 211 to 677 N, and in sample II from 302 to 714 N. This difference in breaking forces should be taken into consideration in cutting car seat covers so that the warp direction is in the direction of the highest stress of the car seat cover. Elongation-at-break also differs in the directions of samples III and IV, ranging from 16.6 to 25.7%, whereas in case of the seamed fabric it ranges from 14.4 to 16.3%. Elongation-at-break is higher in the case of lower breaking forces where artificial leather or woven fabric is the most sensitive (elongation direction along the lines closed by angles of 60^0-240^0 and 150^0-330^0, Figs. 3 and 4).

Breaking force in the warp direction on the samples of artificial leather with seamed woven fabric in the weft direction is lower than in the seamless samples (582 N), as well as elongation-at-break, meaning that seams should be avoided on car seat covers, especially in places with higher stress. The samples of artificial leather with knitted fabric on the back side have the highest average breaking force, which is slightly lower than on the samples with woven fabric on the back side. The highest breaking force is found in the longitudinal direction of artificial leather and knitted fabric, amounting to 578 N (sample III) and 606 N (sample IV). The breaking forces of the samples of artificial leather and knitted fabrics in the cross direction do not differ remarkably, amounting to 552 N (sample III) and 581 N (sample IV).

Likewise, there is no notable difference in amounts of breaking force in the other directions, as with the woven fabric, ranging from 377 N to 606 N on sample III and from 404 N to 578 N on sample IV. The seamed

samples also have lower deviations than the seamless samples in the cross direction, amounting to 471 N (sample III) and 478 N (sample IV). Elongation-at-break is relatively homogeneous in the seamless samples, ranging from 17.7 to 22.2%, and in the seamed samples is more homogeneous, ranging from 14.2 to 14.9%.

The samples of artificial leather with woven fabric on the back side have a breaking force during the ball burst test of 2,186 N/m^2 (sample I) and 2,249 N/m^2 (sample II), and with knitted fabric on the back side 2,004 N/m^2 (sample III) and 2,110 N/m^2 (sample IV). According to the test results it is evident that the artificial leather with woven fabric on the back side has a slightly higher force than the knitted fabric, namely in the warp direction or in the length of the artificial leather, and in the weft direction or in the width direction of the artificial leather. However, the breaking force of the artificial leather with woven fabric in other (diagonal) directions is lower than the breaking force of the artificial leather with knitted fabric.

Average elongation-at-break is higher in the samples with knitted fabric (30.3% - sample III and 33.1% - sample IV) in relation to the samples with woven fabric (24.5% - sample I and 27.1% - sample II). This shows that the artificial leather with woven fabric on the back side is stronger. Using a woven fabric produces a more stable and firmer artificial leather with better durability. Likewise, the woven fabric is more sensitive to stresses in diagonal directions and this is to be kept in mind when spreading and cutting patterns form the fabric.

The samples of the artificial leather with woven fabric on the back side have higher breaking forces in the warp and weft direction in relation to the cross and longitudinal directions of the artificial leather with knitted fabric on the back side. However, breaking forces in other directions deviate more in the samples of the artificial leather with woven fabric on the back side than those with knitted fabric on the back side. This means that the seat covers of the artificial leather with woven fabric on the back side will be more durable and stable than the samples of the artificial leather with knitted fabric on the back side, but only if they are stressed in these directions. However, if most stresses of the seat covers occur during sitting, stress dissipates in all directions. This is the reason why the artificial leather seat cover with woven fabric on the back side irreversibly elongates more in the other dircections 30^0 and 210^0, and 60^0 and 240^0, since it is weaker in these directions. In the case of the knitted fabric this difference is smaller, but their drability is shorter.

According to the results for the breaking forces of the samples of the artificial leather with woven fabric and knitted fabric on the back side, it may be expected that the samples with a higher breaking force will have a higher abrasion resistance and thus be more durable. By correct spreading the cutting parts into the warp and weft direction in the case of the artificial leather with woven fabric on the back side as well as into the cross and longitudinal direction in the case of the artifical leather with knitted fabric on the back side, the durability of the car seat covers and their stability may increase to a large extent which is excepitonally important.

Conclusions

Artificial leather designed for car seat upholstery has to meet many required specifications for strength, breaking force, abrasion resistance, durability, etc. To meet all those demands, artificial leather is joined on the back side with the woven or knitted fabric and polyurethane foam. According to the test results, samples of artificial leather with woven fabrics on the back side have a higher breaking force than samples of artificial leather with knitted fabric on the back side, namely in the warp direction or longitudinal direction as well as in the weft direction or cross direction. However,

breaking forces in other diagonal directions are higher in the samples of artificial leather with knitted fabric on the back side. The shortcoming of the woven fabric is an irregular breaking force of the samples along the angles from 0^0 - 360^0, whereas the knitted fabric has more uniform breaking forces in all directions. This means that more care is necessary when cutting parts are spread so that the direction with greater stresses should be in the warp direction. Diagonal directions have lower breaking forces so that this direction should be avoided when cutting. When seats come under pressure, the fabric is stressed in all directions, and it is difficult to isolate stress in only one direction.

These fabrics are mostly made from single cotton yarns, and very rarely from ply yarns, mostly because of economic reasons. They are woven in plain weave and with a relatively low density. By increasing the density of woven or knitted fabric, greater thickness, stability and stiffness of the artificial leather results. The knitted fabrics are made of plied cotton yarn on the warp knitting machine. They impart elasticity and strength to the artificial leather.

The samples of the artificial leather with knitted fabric on the back side also have a slightly higher breaking force in the length direction in relation to other directions, but the samples with knitted fabrics are more uniform than the samples with woven fabrics. On the other hand, the knitted fabric in comparison to the woven fabric showed smaller breaking forces, but a higher elongation-at-break and a higher regularity of the measured values along all tested directions. The samples of the artificial leather with woven fabrics have a higher bursting strength and a smaller elongation at break than the samples of the artificial leather with knitted fabric.

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