

Innovative Processes for the weaving of stretch Fabrics for Technical Textiles

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Abstract:

Along with all the developments in the different methods of textile production, technology and skills are also developing, which in turn pushes productivity forward. Functional design and high performance of the fabrics, specially intended for mobiltech, represent the main demand of safety guarantee. The vehicle seats are used up during the time life of the car, as they are difficult to change or repair their upholstery. Because of this reason, many specified characteristics have to be available in them; dimensions stability and durability play important roles. Both of these characteristics, in essence, depend on elastic properties of the fabric. Hence, the study of elasticity of fabrics is important both from theoretical and practical aspects.

This present paper aims at the utilization of different textile materials on the weaving process to produce creative and functional effects, as well as establishing the influence of structural parameters on the tensile properties of the fabric.

The study spots the light on the dimensional stability of the fabric which measures its extent to keep its original dimensions subsequent to its manufacture. It is possible for the dimensions of seat-fabric to increase or decrease according to the applied forces during their usage. When the textile material is stretched by a force that is below the level of its breaking strength and then is allowed to recover, it doesn't immediately return to its original length. The recovery time depends on the physical properties of the fabric and on the other side the time at which the force is applied on the fabric.

The extent of recovery from the extension is a property, which is dependent on the type of material, which held at a given extension for a fixed length of time before removal of the force, the elastic recovery increases with time, rapidly at first and more slowly later.

The used materials for warp and weft yarns of the seats have to be more elasticity and the fabric structures also have to be built with this a practical point of view.

As it is known, that the percentage recovery decreased steadily with increasing extension of the material up to the yield point where the recovery decreased sharply. For this reason, the tensile strength and extension of the fabric structures have to be studied in this paper. Whole allows a better comparison of textile materials to be made as it contains more information about the behavior of the material under stress than do the simple figures for tensile strength and extension.

Keywords:

Elastane core yarns (EL)

Double-covering yarn

Mobiltech

Stretch fabrics

Thickness

Tensile Strength

Extension

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1. Introduction

In the field of technical textile, there are 150 end-use products, which have been quantified separately are grouped into the 12 Application Areas. The transportation sector (Mobiltech) represented 15% of the world market end-use consumption of technical textiles in 2014 [2]. These textiles are used in the construction of automobiles, railways, ships, aircraft and spacecraft.

1.1 The automotive textiles

There are some unique and extra tough requirements for the properties of automotive textiles such as light-fastness, ageing, emissions, and dirt resistance/-clean ability. The automotive

textiles must have creative designs, flexible production capacity and also the continuous improvement is a necessity. There are plenty of opportunities for growth in automotive textiles which are applied on several surfaces of the car Interior as shown in Fig. 1.

Automotive textiles are a complex and complicated products with great many demands placed upon it. The used fabrics are:

- Knitted, warp-knitted or woven fabric for upholstery and panel applications.
- Tufted or non-woven fabric for carpet applications.

An upholstery textile consists of the textile plus laminate and scrim (hacking), which are normally bonded together by a flame-lamination process,

but a process of glue-lamination has also been developed. Unlaminated textiles are specified for panel and Insert applications, but for carpet applications, different laminations and backings are specified.

A typical price for a material is 5-15 Euro/m², depending on its application and quality level. Table 1 shows some normal coverage figures for a car with textile upholstery and textile-covered panels /3/.

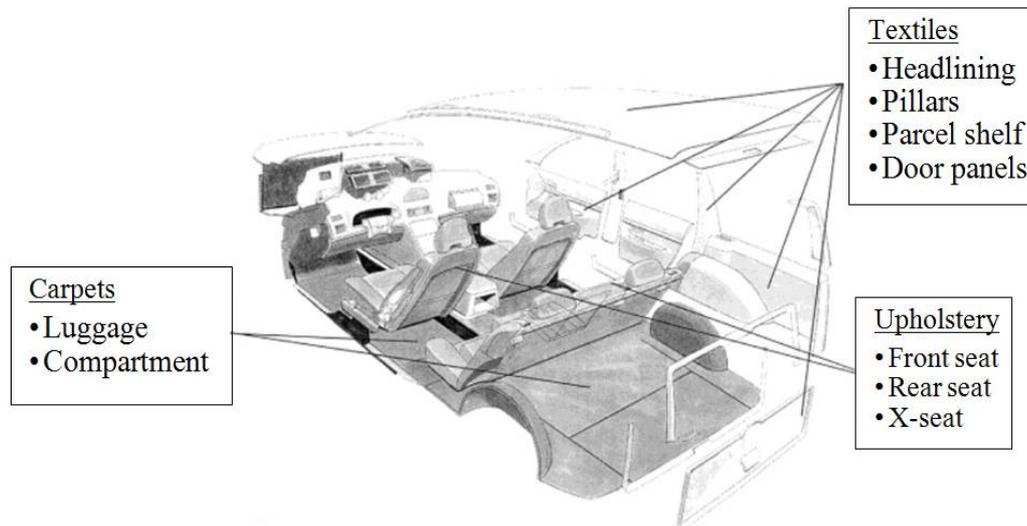


Fig. 1: Diagram of a car interior /3/

Table 1: some coverage figures for a car with textile upholstery and textile-covered panels /3/

Application fields	Area [in m ²]
1 Upholstery	10 m ²
2 Door panels	2 m ²
3 Pillars	2 m ²
4 Carpet	4 m ²
5 Parcel shelf	1 m ²
6 Headlining	4-6 m ²
7 Luggage Compartment	4-5 m ²
8 Seat belts	0.5 m ²
9 Airbags	3.5 m ²
Total	31-34 m ²

1.2 Elastane fiber (EL)

Elastane yarns are often used to produce stretch fabrics on knitting machines as well as rapier weaving machines, but it is still limited on air-jet weaving machine. In this paper, an attempt was made to develop the executive methods for the weaving of elastomeric polyurethane yarns, with a view to the production of automotive textiles suitable for their end-use. Elastomeric polyurethane has been increase used in the textile industry during recent years. The uncovered elastane yarn is not used for weaving; it is always combined or covered with other yarns or fibers. The texture of covered elastane yarn has to be looked like the exterior of traditional yarn. Using elastane on the weaving machine requires more knowledge about fiber characteristics and their effects on both process ability and properties of resultant textiles /4, 5/.

1.2.1 Distinguishing attribute of Elastane fiber

Elastane fiber (EL) is a synthetic filament yarn; its

macromolecule composed of at least 85% by weight of segmented long chains of polyurethane. If it is stretched to three times as its unstretched length, it reverts rapidly substantially to the unstretched length when the tension is removed /4/.

1.2.2 Elastane (EL) chemical formulae

Isocyanic salt is used for fiber production; it contains carbon, hydrogen, oxygen and nitrogen as represented in Fig. 2. By using isocyanic salt, the isocyanate is superimposed on an alcohol and the Glycol with the result to produce the monomeric alkylurethane, which is called urethane. Polyurethane is spun in melt spinning process. Macromolecules have alternate elastic and rigid segments with repetition of the group /6/.

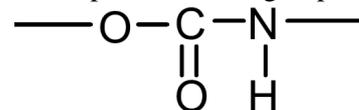


Fig. 2: Elastane (EL) chemical formulae /6/

1.2.3 Morphological scheme for elastane covered yarns

It is a general term for elastic yarn with bare elastane core covered by one or more relatively inelastic textile components. Several processes are in use to combine elastane with other fibres to produce elastic yarns for textile applications. There are four main methods to cover an elastane yarn; single core twisting, double core twisting, core spinning and air covering. This research interested in the utilization of double core twisting elastane on the weaving machine. From this point of view; the constructions of core twisting yarns

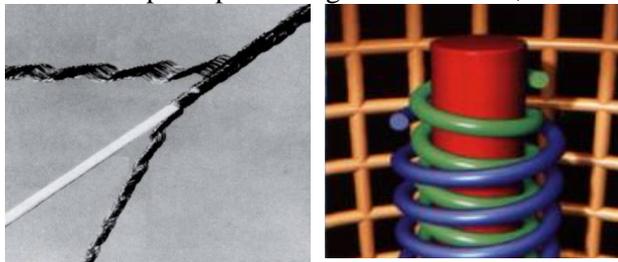
are divided into the following items:

1.2.3.1 Core-textured yarn (single core twist)

Elastane yarn (core) covered by one relatively inelastic cover yarn continuously textured together with the core entwined by the filaments with false twist turns of randomly changing directions. The elastane yarn is pre-tensioned and is passed through a first hollow spindle on which the inelastic yarn is located that is twisted around the elastane yarn /4, 6/.

1.2.3.2 Double covered yarn (double core twist)

Elastic yarn with bare and twistless elastane core and two relatively inelastic yarns wrapped around the core with continuous turns in opposite directions as represented in Fig. 3. In the double core twist process, the elastane yarn is then passed through another hollow spindle working according to the same principle of single core twist /4, 6/.



a. Actual yarn b. Simulated yarn

Fig. 3: Double-covering yarn /4, 5/

2. Materials and Methods

2.1 Analysis of the Problem

The exchanged strains between warp and weft yarns during weaving have to be translated to stretching forces in the woven fabrics. That affects the changing of the fabric dimensions after releasing from the weaving machine. Warp-tension introduces strain to the warp yarns, on the other side, there is also a generated tension has to be created on the wefts in the distance between weft supply unit and weft insertion method. This tension imparts strain to the weft yarns. Certainly, the equilibrium of internal forces of elasticity between warp- and weft yarns of the fabric have to cause immediate and complete relaxation shrinkage for the fabric after releasing from the weaving machine.

2.2 Theory of technology

There are many factors affect the fabric elasticity behavior after releasing from the weaving machine; these factors could be enclosed in:

1. The physical properties of materials are the main items which have the influence on dimensions stability and mechanical properties of the woven fabric after relaxation.
2. The variety in executive methods by changing the applied tension values of elastane core

yarns must be affected in the fabric properties, especially its elasticity behavior.

3. The different values of applied tension on elastane core yarns must have a clear effect on the elasticity behavior of the fabric even if the fabric structure isn't changed.

2.3 Development of woven structures of stretch Fabrics

1. The difference in fabric constructions which represent the interlacing shape between warp- and weft yarns must have an effect on the contraction of fabric-relaxation.
2. The vehicle seats' fabrics have to be more flexibility and strength than the traditional fabrics with similar specifications.

2.4 Development of the executive methods

To achieve the required properties of vehicle seats' fabrics as mentioned above, some procedures have to be carried out on the weaving machine.

These procedures can be defined as follows:

1. Two warp beams would be used for PCF textured yarns, the warp tension values have to be varied according to the fabric structure, as mentioned later.
2. Cones creel has to be used for Elastane core yarns (EL), the tension values have to be varied according to the fabric structure.
3. The tension-control mechanism of Elastane (EL), has to be similar the technology that is used on the warp beaming machines (Yarn disc tensioner).
4. The weft tension values and the weft density have to be restricted for all fabric structures.

3. Experiments

The experimental work had carried out on Dornier rapier weaving machine model PTSL 16, (Lindauer DORNIER GmbH Company, Germany). The machine equipped with three warp beams and max. 20 healds frames.

3.1 Weaving procedure

The experimental samples had been woven by using PCF textured yarns for the warp and weft yarns and Elastane (Double core twist yarn) as warp yarns. The fabric constructions enclosed in plain weave 1/1 which based on double-weave technique. The main structural elements of the woven stretch fabrics are represented in Tab. 1. On the other side, Fig. 4A shows cross-sections in warp direction for the interlacing of warp and weft yarns and Fig. 4B shows weave diagrams for fabric constructions of the samples. The drawing-in system for all fabrics' constructions are illustrated in Figure 5.

Materials	Warp	Warp type	PCF textured yarns	Elastane (Double core twist yarn)
		Count in denier	1200	2400
		Arrangement	2:1	
Structure	Weft	Weft type	PCF textured yarn	
		Count in denier	1200	
		Construction	Plain weave 1/1 based on double-weave technique	
Sample width (in the reed)	140 cm.			
Warp Density	yarns/cm	12	6	
Draft system	No. of healds	4	2	
Denting system	Reed 12 (dent/cm)	2 PCF textured : 1 Core-textured		
Weft density	wefts/cm	10		

Table 1: The structural elements of the woven experimental samples

3.2 Quality and security procedures

As a result of using elastane core yarns (EL) as a warp, some procedures have to be taken into consideration:

1. The tension values of Elastane core yarns (EL) have to be tested, evaluated and controlled during the weaving process by using a special device.
2. Elastane yarn-cones on the creel have to be

covered by silk socks for more security against yarn-slippage from the cone.

3. Elastane core yarns (EL) must be drawn in through the first and second healds frames as shown in Fig. 5.
4. According to the sensitive of elastane against friction parameters on the weaving machine, elastane yarns must be dented individually in the weaving reed.

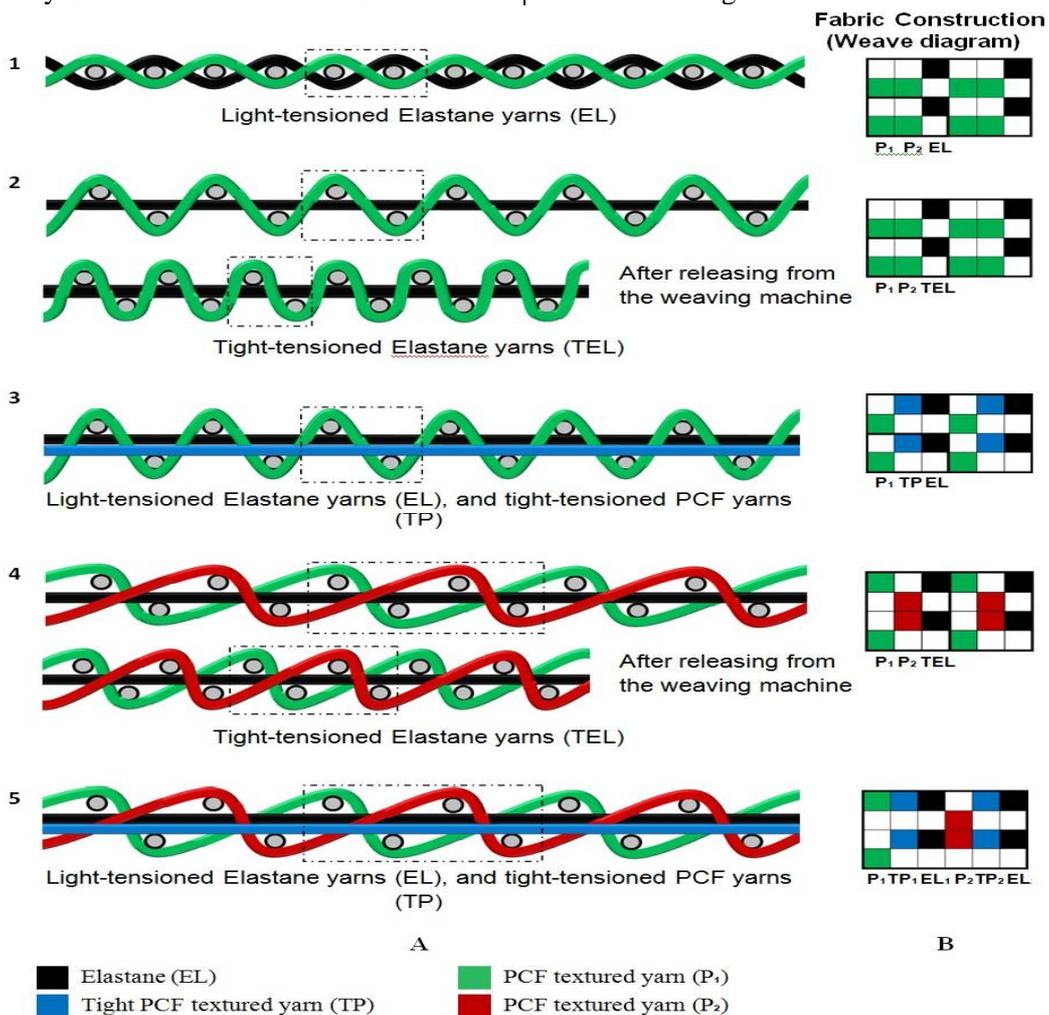
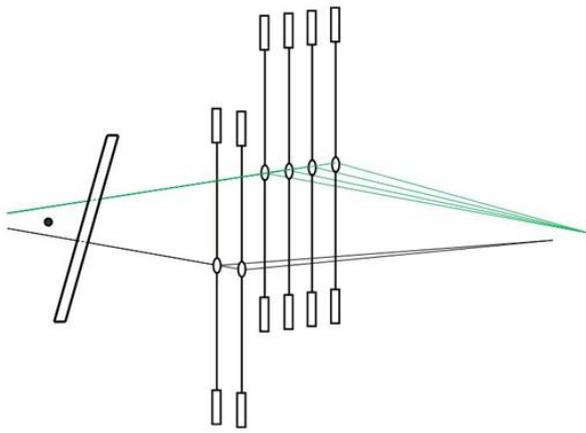
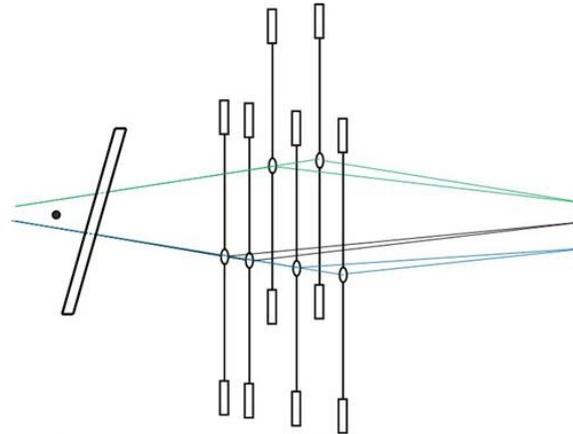


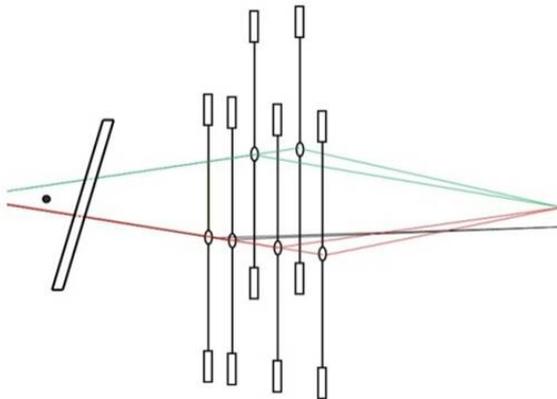
Fig. 4 Cross-sections in warp direction for the interlacing of warp and weft yarns (A), and Weave diagrams for fabric constructions of the samples (B)



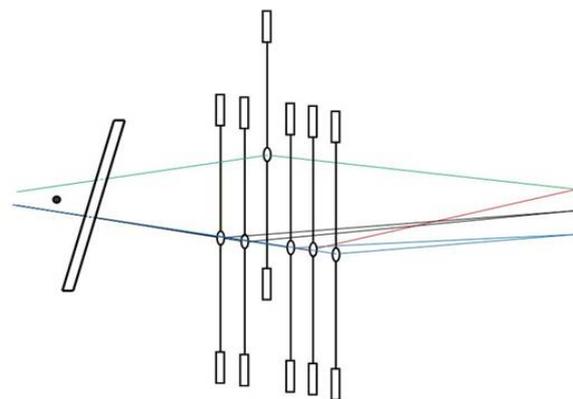
Drawing-in system of the construction 1 and 2



Drawing-in system of the construction 3



Drawing-in system of the construction 4



Drawing-in system of the construction 5

Fig. 5: Drawing-in systems for all fabrics' constructions in Figure 4

3.3 Laboratory tests

Laboratory tests had been performed by standard rules, which are recommended by the German Institute for Standardization (Deutsches Institut für Normung, DIN). The laboratory tests have limited in tensile strength test, as well as fabric thickness for the fabric samples.

4. Results and discussions

The main purpose of this analysis is to discuss the effect of the fabric structure elements in fabric thickness, tensile strength and extension values. The fabric structure elements were determined by the difference in elastane (double core twist yarn) and/or PCF textured yarn tension values during weaving and the difference in fabric constructions as illustrated before in Figs. 4 and 5.

The comparisons between the structures of experimental samples which determined in structures 1, 2, 3, 4 and 5 which all of them based on plain weave 1/1 (structures 1, 2 and 3) or plain weave based on the double-weave tying from warp and weft (structures 4 and 5).

4.1 The effect of the fabric structure elements in the fabric thickness values

Fig. 6 shows comparisons between thickness

values for different structures of the fabric samples. From these comparisons, it was found that the fabric thickness values were changed according to the change in fabric structures and/or warp yarn tension. The plain weave based on the double-weave tying from warp and weft (structure 4) achieved the highest value of the thickness follows with structure 5 and plain weaves 1/1 achieved the lowest values. There were also very big differences between the average values of the thickness for plain weaves 1/1 (Structure 1) and its similar structures (Structure 2 and 3) in which tightly tensioned elastane yarns (TEL) or tightly tensioned PCF yarns (TP) were used respectively.

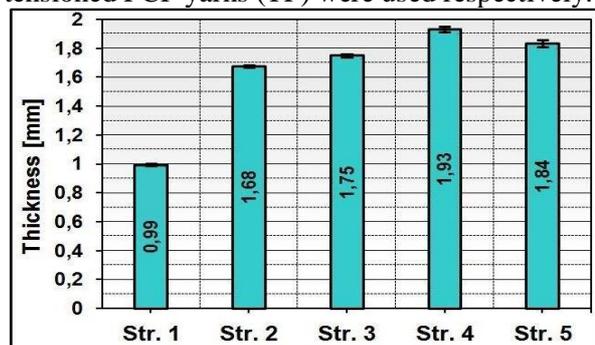


Fig. 6: Comparisons between thickness values for different structures of the samples

There was also a difference between the average values of the thickness for plain weaves based on the double-weave tying from warp and weft (Structure 4) in which tightly tensioned elastane yarns (TEL) and its similar structures (Structure 5) in which tightly tensioned PCF yarns (TP) were used respectively.

From a practical point of view according to the results of thickness test, it is found that the difference in the thickness values between the fabric structures can be limited in the next points of view:

1. During weaving process, the warp yarns undergo various deformations which are tensile, bending, internal friction and exchanged pressure forces (compression) with weft yarns.
2. The fabric thickness value of structure 2 is more than its similar of structure 1, this result comes back to the contraction of the tightly tensioned double core twist yarn (EL) after releasing from the weaving machine. The contraction force pushes the weft yarns up and down elastane yarns, which tend to be straight as represented in Fig.4. On the other side, the behavior of wefts up or down tend to come near each other's and wefts' density has to be increased. All of that affect positively in the increasing of crimp values of warp yarns (PCF), and hence the high value of thickness compared with structure 1.
3. The behavior of tightly tensioned PCF yarns in structure 3 have to be like the elastane in structure 2, but they haven't any contraction force. The wefts density has to be the similar value as structure 1, but the crimp value of lightly tensioned Elastane yarns has to be more than their similar in structure 1 and less than structure 2.
4. The fabric thickness value of structure 4 is more than its similar of structure 5, this result comes back to the contraction of the tightly tensioned double core twist yarn (EL) as mentioned above. The movement-freedom values of plain weave based on the double-weave tying in structure 4 are more than their similar in plain weave, for this reason the structure 5 crimped more than structure 2, and it maintained the highest value of thickness between all samples' structures.
5. The tightly tensioned PCF yarns in structure 3 maintained the weft density value as like as structure 3, so the thickness value was less than its similar of structure 4.

4.2 The effect of the fabric structure elements in the fabric tensile strength and extension

values

During tensile strength test, the responses of samples to applied force and deformation "which caused in consequence of the test" reflect the behavior of fabrics during their utilizations. The importance of tensile strength of the fabric exists in the influence of this factor in the other mechanical properties of any fabrics. From other side of view, these responses represent a simulation for the expected attitude of the fabric against the influential forces.

It is shown in Fig. 7 the comparisons between fabric tensile strength and extension values for different structures of the samples. From these comparisons, it was found that the fabric- tensile strength and extension values were changed according to the change in fabric structures and/or warp yarn tension. The plain weave (structure 1) achieved the highest value of tensile strength follows with structure 2, follows with structure 4, follows with structure 3 and plain weaves based on the double-weave tying from warp and weft (structure 5) achieved the lowest value of tensile strength.

On the other side; The plain weaves based on the double-weave tying from warp and weft (structure 4) achieved the highest value of extension, follows with structure 5, follows with structure 2, follows with structure 2, and plain weave (structure 1) achieved the lowest value of extension.

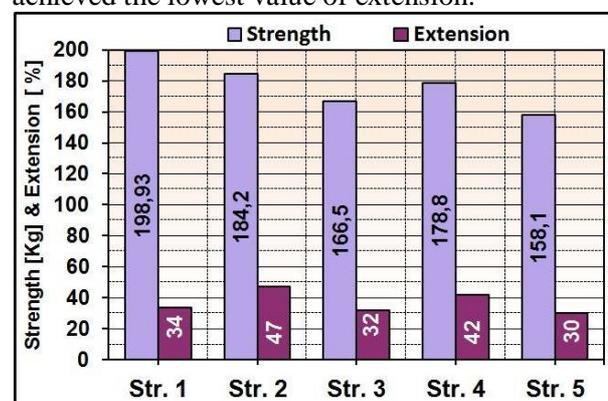


Fig. 7: Comparisons between fabric tensile strength and extension values for different structures of the samples

According to these results, it was found that the difference in the tensile strength and extension values between the fabric-structures could be limited in the next points of view:

1. According to the morphological scheme for elastane, the elastane double core twist yarns had not been shared effectively in the results of tensile strength and extension. Their extension under test force may be more than 400%, anyway this value is just about ten times the extension of PCF yarns, then the PCF yarns

have to be cut and the result is recorded on testing machine, in spite of that the elastane have been remained in their condition. Anyhow the test strip is clamped lengthwise in the flat jaws of the testing machine so that all yarns within the fabric are held the tensile force which is progressively increases /7/.

2. The plain weave (structure 1) achieved the highest value of tensile strength, this result came back to the identical interlacing of all PCF yarns with wefts, and this interlacing-shape made all PCF yarns move identical movement during test. The warp yarns could be easily released from the contractions with wefts and became free of any friction forces, so all warp yarns resisted the tension of the testing machine during test more than any other structures.
3. The reaction of PCF warp yarns of structure 2 is alike their similar of structure 1, but using tightly tensioned elastane as a warp yarns caused the highest value of crimp for their PCF warp yarns after releasing from the weaving machine related to the increasing of wefts density. Owing to this important factor, this structure achieved the highest value of extension compared with all other structures. During test the length of sample between jaws before cutting has to be longer than in structure 1, then the interior reaction and exchanged forces of warp yarns have to be lower than in structure 1, consequently the tensile strength value was lower than their similar in previous structure.
4. The tight of warp yarns in structure 3, which has no crimp with wefts have to be tensioned suddenly during test, at the same time the normal tensioned yarns must be eliminated firstly from their interlacing with wefts. Hence, there was no homogeneity of yarns tension during test and the structure maintained lower values of tensile strength and extension than previous structures.
5. The plain weaves based on the double-weave tying from warp and weft (structure 4) achieved the highest value of extension due to using tightly tensioned elastane as a warp yarns caused high value of crimp for their PCF warp yarns after releasing from the weaving machine related to the increasing of wefts density /7,8/. This structure achieved the high value of extension, but lower than the extension value of structure 2. Structure 4 consists of two groups of yarns; tightly tensioned elastane which worked as wadding layer in the fabric and PCF yarns which interlaced with wefts on

the basis of plain weave 1/1. Anyway the crimp values of PCF yarns were equal and their behaviors during test were similar. For these reasons, the structure 5 achieved high value of tensile strength compared with structure 3.

6. Structure 5 includes between structure 3 and 4 together, the half of PCF yarns were tight tensioned and the second half were normal tensioned. The tight tensioned warp yarns had no crimp have to be tensioned suddenly during test, at the same time the normal tensioned yarns have to be eliminated firstly from their interlacing with wefts. Hence, there was no homogeneity of yarns tension during test and the structure maintained the lowest values of tensile strength and extension.

5. Conclusions

The transportation sector (Mobiltech) represents 15% of the world market end-use consumption of technical textiles in 2010 by application area. Nowadays, every car is already furnished with about 30-40 kg of textile materials and this quantity is rising fast. Moreover, everyone involved in-car manufacture ring is rapidly coming to the realization that textile materials and the technologies implemented to produce them are among the essential key technologies for mobility. This present paper aims at use of different textile materials on the weaving process to produce creative and functional effects, as well as establishing the influence of structural parameters on the thickness and tensile properties of the fabric.

The dimensional stability of the fabric keeps its original dimensions during their use. It is possible for the dimensions of seat-fabric to increase or decrease according to the applied forces during their usage. When textile material is stretched by a force that is below the level of its breaking strength and then is allowed to recover, it doesn't immediately return to its original length. The recovery-time depends on the physical properties of the fabric and on the other side the time at which the force is applied on the fabric.

Using elastane yarns affect on the interlacing form of fabric construction not only on the weaving machine after weft beating-up owing to the difference in warp tension values, but also on the physical properties of the fabric after releasing from the weaving machines.

It was found from the test-results of this paper that participation of elastane (Double core twist yarn) as a warp on the vehicle seats' fabrics reduces the recovery-time for the fabric to return to its original dimensional, but on the other hand elastane yarns didn't affect positively in the fabric tensile

strength. From other point of view, the results have assured that elastane yarns affected positively in the fabric thickness.

References

1. **B P Saville**: Physical Testing of Textiles. Cambridge, UK: Woodhead Publishing Limited, 1999. – ISBN 1-855-73367-6
2. **David Rigby Associates** World Markets for Technical Textiles: Forecasts to 2010. Frankfurt am Main, Germany: Messe Frankfurt (Firm), 2009. – ISBN 1-90262-562-5
3. **Roshan Shishoo** Textile Advances in the Automotive Industry. Cambridge, UK: Woodhead Publishing, 2008. ISBN 978-1-84569-331-2
4. **Rolf Hesse** Textile Fasern. Frankfurt [Main], Germany: Deutscher Fachverlag, 1988.- ISBN 3-87150-274-X
5. **Ursula Völker, Katrin Brückner** Von der Faser zum Stoff / Textile Werkstoff- und Warenkunde. Hamburg Germany: Handwerk u. Technik Büchner, 2001. – ISBN 3-582-05112-9
6. **BISFA Bulletin**: Internet site of Institut für Spezialtextilien und flexible Materialien. Terminology of man-made fibres; The International Bureau Of Standardization Of Man-Made Fibres. Brussels, Belgium, 2006 <http://www.titv-greiz.de> (2008-2012)
7. **Said Badawi**: Enhancement of the Characteristics and Features of Woven Safety Belts to be a High Functional and Performance Material for using in Transportation Sectors (Mobiltech). The 3rd International Conference of the Faculty of Applied Arts, Egypt, Cairo, 11-13 Dec. 2013, Vol.1, No. 1, Page 213.
8. **Said Badawi**: A Development of Weaving Procedures for the Hollow Filament Fibers for using in the Field of Medical Textiles (Medtech). The 2nd International Conference, The Future of Egyptian – Chinese & Arab-Chinese Relationships in the 21st Century, Egypt, Cairo, 17-18 Mar. 2013, Vol.2, No. 3, Pages 81-100.