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Spacer-type structures for hernia repair

Emilia Visileanu, Maria Memecica, Razvan Scarlat,Alina Vladu
The National Research and Development Institute for Textiles and Leather
16, LucretiuPatrascanu street, Bucharest , Romania
Corresponding Author: Emilia Visileanu

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ABSTRACT: Spacer fabrics are three dimensional knitted fabrics which consist of two fabric layers combining with a spacer yarn. The characteristics of spacer fabrics become a highly interested concept for textile researchers because of increasing usage in various areas. In this study the physico-mechanical characteristic which are important properties of spacer fabrics for hernia repair, was investigated. Fabric samples were produced using different spacer yarn types and various materials for back and face surfaces of the fabrics for dial heights. It was found that the anisotrpy of the spacer fabrics is affected from the spacer yarn type, dial height and surface material.

KEYWORDS: hernia mesh, spacer, knitted structure, physical properties, mechanical properties

I. INTRODUCTION

Knitted preforms based on Spacer (Sandwich) type structures are used in special fields: machine-buildingindustry, aeronautical industry, where light materials are required. In addition to the improved mass/strength ratio, knitted preforms have high tensilestrenght, bending, and impact coefficients.

A Sandwich knit is a three-dimensional construction composed of two or more surfaces connected through connecting layers.

The classic system for making Sandwich type structures (weaving or knitting on circular machines) involves tying the layers by threads. The disadvantage of these technologies is given by the limited distance between the two connected surfaces.

The bonding layers can be knitted in two ways: in one layer and two layers (fig.1). If you choose the variant with a single connecting layer, it is made on a single font, in the smooth structure, or on two fonts, in the patent and interlock structure. The arrangement of the layer may be perpendicular to the base layers or inclined arrangement. In the case of the second variant, with two layers of connection, they are knitted individually on the two fonts and interconnected at certain points.

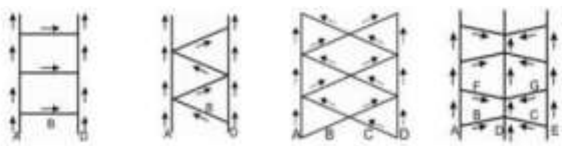

Fig. 1. Examples of sandwich knits with two and three layers of binding

The production of preforms requires three-dimensional production technology, which can be accomplished by rectilinear knitting machines controlled by a microprocessor.

These machines are equipped with electronic needle level selection, integrated cam systems for knitting or transfer, the possibility of lateral movement of the rear cast iron, main pullingmechanism, auxiliary pulling mechanism, concentrated pulling with closing-throwing plates and adaptable power supply. These technological features offer the possibility of making technical knits with three-dimensional applications with the help of rectilinear knitting machines.

The shape of Sandwich knits can vary depending on the size of the bonding layer, the spatial contouring. By varying the size of the layers, a change in the cross-section of the shape is obtained (fig. 2).

The spatial contouring of the shape is done by narrowingand enlargements made by mesh transfer and font displacements.

Fig. 2. Sizevariations

II. EXPERIMENTATION

For the development of the Spacer-type textile structures, the knitting machine from Shima Seiki SIG 123 of E8 fineness was used (fig. 3). SIG123 features SHIMA SEIKI's new Rapid Response R2CARRIAGE system, which makes the trolley turn faster after each stroke. Thus, less space is needed for turning, which allows the area to be increased for running at maximum speed. This allows faster knitting along the way, generating a productivity increase of over 10%.

The knitting experiments on the Shima Seiki SIG 123 machine aimed at creating Spacer-type textile structures in the following variants:

a) Spacer I - layer I of polypropylene (PP) monofilament yarns and layer II of polylactic acid (PLA) monofilament yarn with the connecting wire between layers made of Ag;

b) Spacer II - layer I of polyester(PES) multifilament yarns and layer II of PLA mono-filament yarn with the connecting wire between layers of Ag.

Fig.1. ShimaSeiki SIG 123

The design set-up of the Spacer-type structures and the working parameters are presented in table 1.
In fig. 4 and fig. 5 the cross-sections of the Spacer I and Spacer II structures are presented.

Fig. 4. Spacer I cross-section

Fig. 5. Spacer II cross-section

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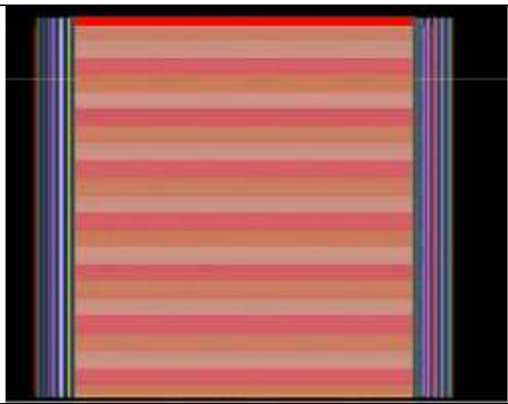
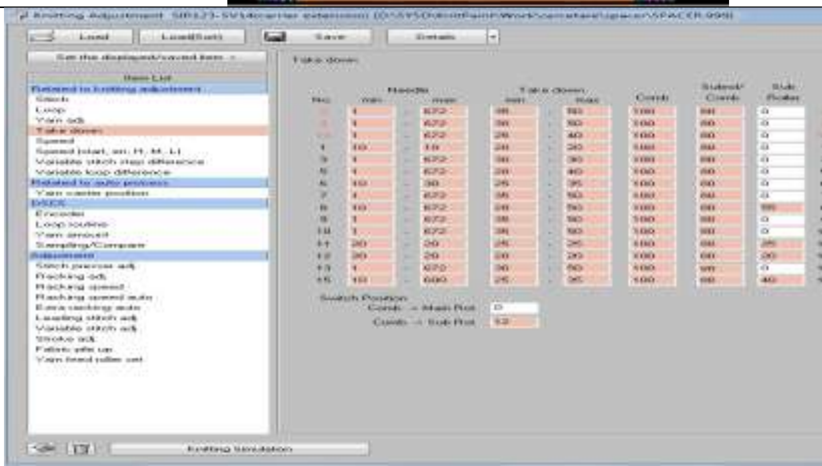
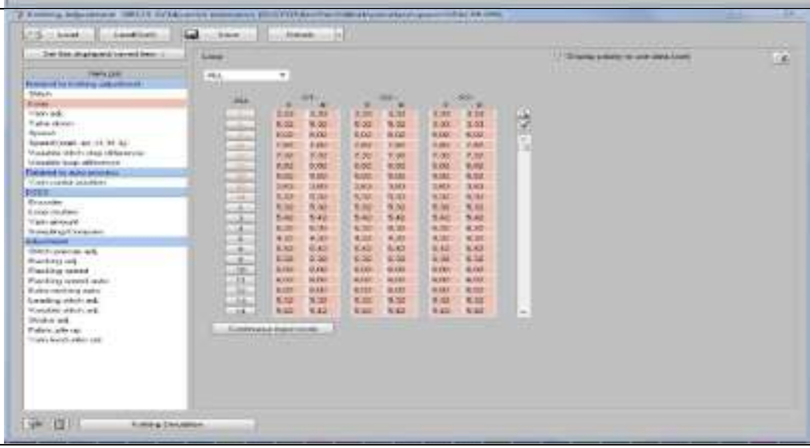
The developed textile structures were finished on the laboratory equipment in INCDTP with the following technological flow:

- Washing-degreasing with 2 g/L sodiumcarbonate, 2 g/L sodium hydroxide at 38ºC, 2 g/LKemapon PC/LF, 2 g/L trisodium phosphate, for 30 min at 60ºC
- Rinsing with water at 60, 40, 20ºC
- Rinsing with distilled water
- Laser or mechanical cutting to the dimension of 10/10 cm or 20/20 cm
- Packaging in STERIDIMOND type packaging
- Sterilization with ionizing radiation

Table 1

Parameter	Design set-up
Spacer – program	
Spacer – Pulling adjustment	
Spacer - Densityadjustment	

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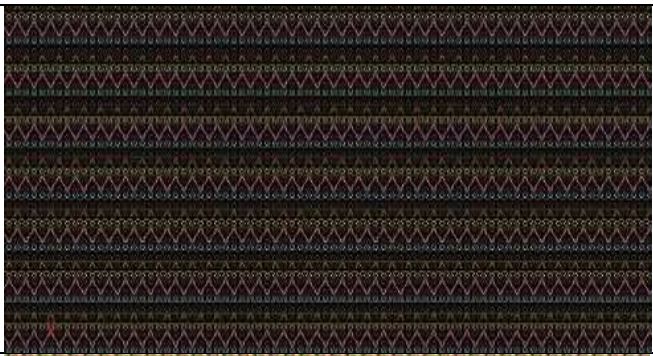
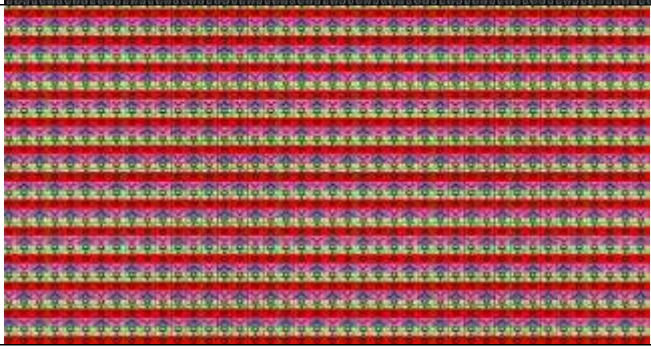
Spacer – Section	
Spacer – Structure	

The shape and meshes dimensions for the Spacer I and Spacer II structures were determined using the Projectina optical microscope and are shown in Table 2. The area S (mm^2) and perimeter of the meshes P (mm) were determined. The pore surface is 0.59 mm^2 for the Spacer I structure and 0.64 mm^2 for the Spacer II, and the perimeter is 3.38 mm and 3.2 mm, respectively.

Table 2

No.	Variant	Structure			Mesh shape	Dimensions
		SI	SII	Slink		
1	Spacer I	PES	PLA	Ag	 	S = 0,59 mm^2 P = 3,38 mm
2	Spacer II	PP	PLA	Ag	 	S = 0,64 mm^2 P = 3,2 mm

III. DISCUSSIONS

Table 3 presents the physicomechanical characteristics of the finished Spacer-type structures. The analysis of the data presented in table 3 shows the following aspects:

- the mass (g / m^2) of the Spacer structures places them in the category of high mass nets (> 60 g/m^2) due to the presence in the structure of 4 categories of PES, PP, PLA, and Ag yarns
- breaking strength (N) on the vertical direction is about 14% higher in the ES2 variant (PP + PLA + Ag) compared to the ES1 variant (PES + PLA + Ag); on the horizontal direction, the difference is approx. 27% in favor of the ES2 variant.
- elongation at break (%) on the vertical direction is comparable between the two variants (87.7 and 83.8%); horizontal elongation is better in the ES1 variant (37.3%) compared to 75% (too high) in the ES2 variant
- the thickness is higher for ES1 (1.58 mm) compared to ES2 (1.30 mm); - the deformation resistance is higher at ES2 (286.6 kPa), but the deformation is also higher (44.4 mm) compared to the ES1 variant (277.7 kPa and 41.3 mm respectively).

The shape and dimensions of the pores in the finished Spacer-type structures are presented in table 4.
From the analysis of the data presented in table 4 results that the surface and the perimeter of the pores of the finished Spacer-type structures, decreases at both variants ES1 and ES2 compared to the unfinished structures.

Table 4

No.	Variant	Poreshape	Dimen-sion	Surface
1	ES1 PES+ PLA+Ag		l = 27×20 = 540 µm	S = 0,29 mm^2 P =2,16 mm
2	ES2 – PP+ PLA+Ag		l = 40×20 = 800 µm	S = 0,34 mm^2 P = 1,58 mm

SEM and EDAX analysis

The SEM images, and the EDAX spectra of the Spacer-type textile structures are presented in table 5. From the analysis of the SEM images the presence of PLA monofilament and multifilament yarns can be observed from PES and Ag connecting yarns in the case of ES1 structure and the presence of PP monofilament yarns, PLA and Ag connecting wires for ES2 structure.

Table 3

No.	Characteristic			UM	Variant: Spacer – ES1 PES+PLA+Ag	Variant: Spacer – ES2 PP+PLA+Ag	
1	Composition			%	14% PES + 43,3% PLA + 42,7% Ag	53,3% PP + 41,6 PLA + 5,1% Ag	
2	Mass			g/m^2	169,9	169,7	
3	Density	Ho		No of meshes/ 10 cm	64	64	
		Vert	PES		120	PP	105
			PLA		120	PLA	105
			Ag		120	Ag	120
4	Breaking resistance	Vert		N	205,4	245,4	
		Ho			26,2	36,3	
5	Elongation at break	Vert		%	87,7	83,8	
		Ho			37,3	75,0	
6	Thickness			mm	1,58	1,30	
7	Deformation resistance			kPa	277,7	286,6	
				mm	41,3	44,4	

The analysis of the elemental composition shows the following aspects:

- elemental Ag is found in the largest proportion in both structures - 49–46%, followed by

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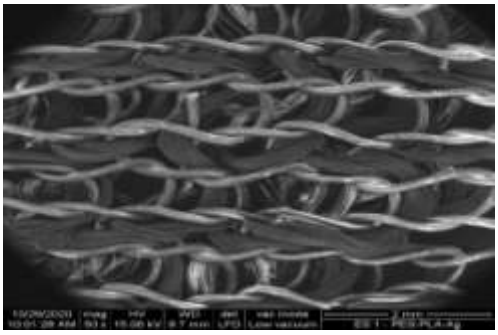
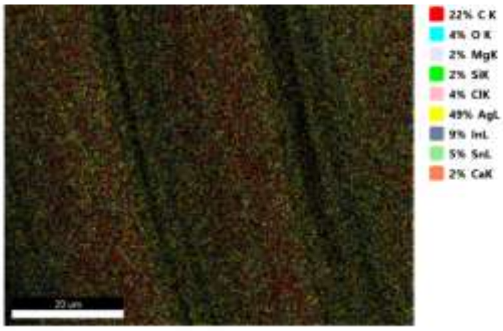
Carbon(22–27%), Indium (9%), Tin (4–5%), Chlorine (4%) and Oxygen (4%);

- also identified: Magnesium (2–3%), Calcium (2%).

Table 5

<table>
<tr><td colspan="2">ES1-PES+PLA+Ag</td></tr>
<tr><td></td><td>
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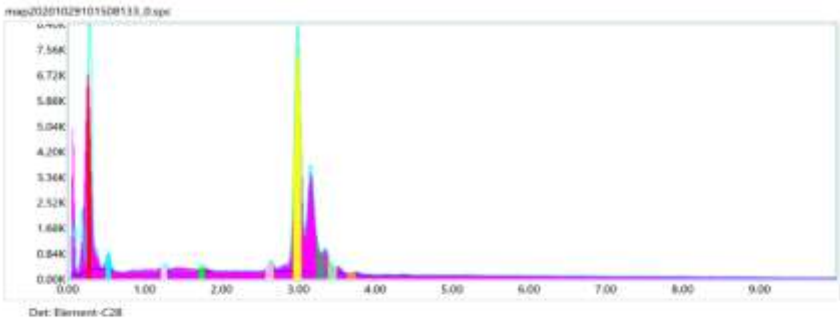
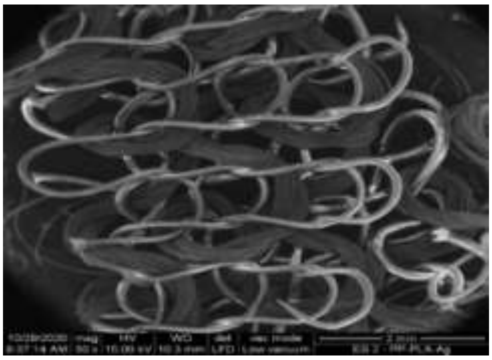
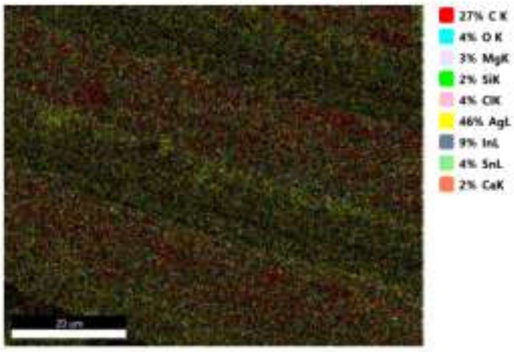
<tr><td colspan="2">
</td></tr>
<tr><td colspan="2">ES2-PP+PLA+Ag</td></tr>
<tr><td></td><td>
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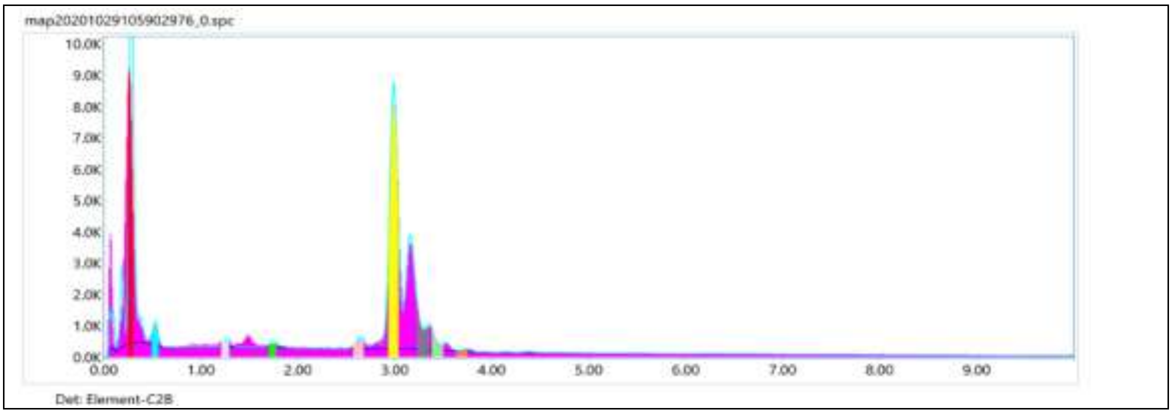


Modulus of elasticity and anisotropy

Table 6 shows the stress-elongation curves, and Table 7, the calculation elements of the modulus of elasticity, the values of the modulus of elasticity and anisotropy, for the textile structures ES1 and ES2. From the analysis of the data presented in table 6, the following aspects can be identified:

- the modulus of elasticity of the functional models ES1 (PES + PLA + Ag) and ES2 (PP + PLA + Ag) classifies them in the category of small modules nets (in both directions <10.9 MPa) that allow them not to generates large shear forces in the abdominal cavity;
- the anisotropy of the Spacer-type structures - ES1 and ES2 is very good, being in both cases <1.0 (0.90 and 0.51 respectively).

Table 6

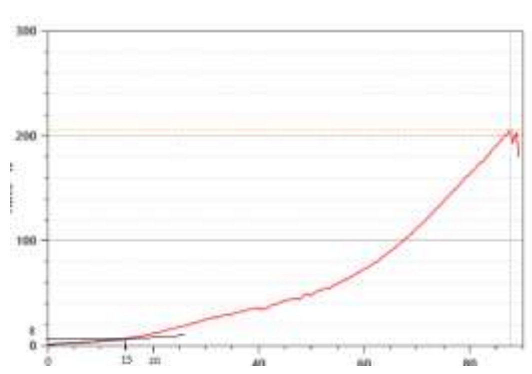
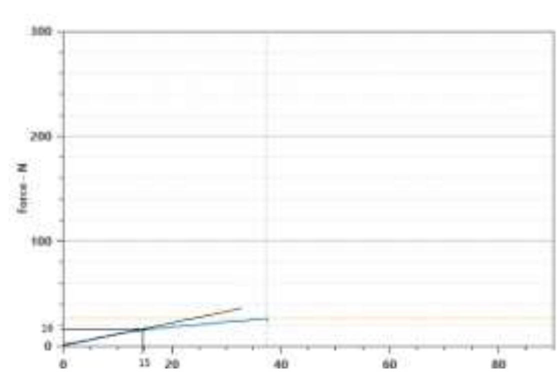
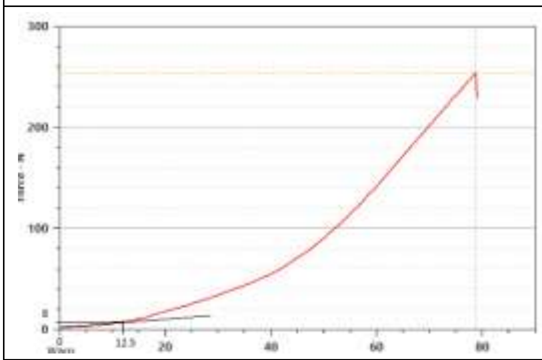
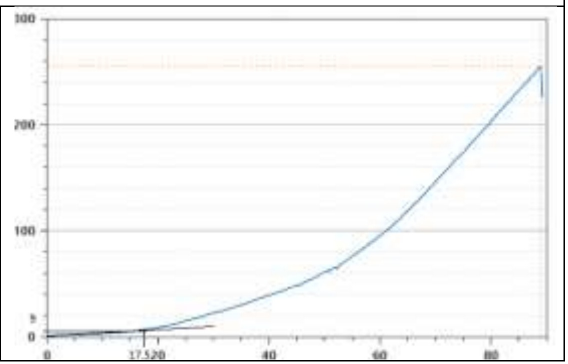
ES1	
warp	weft
	
ES2	
	

Table 7

No.	Variant	Parameters								
		Force [N]	L_0 [cm]	L_1 [cm]	ΔL [cm]	A [cm^2]	G [cm]	Elasticity		Anisotropy
								[N/cm^2]	[MPa]	$log \frac{E_{weft}}{E_{warp}}$
1	ES1 warp	8	20	23	3	3.16	1.58	16.88	0.17	0.90
	ES1 weft	16	5	5.75	0.75	0.79	1.58	135.02	1.35	
2	ES2 warp	8	20	22.5	2.5	2.6	1.3	24.62	0.25	0.51
	ES2 weft	9	5	5.875	0.875	0.65	1.3	79.12	0.79	

IV. CONCLUSION

Spacer-type functional models were made of: PP + PLA and PES + PLA with Ag connecting wire, having a trapezoidal pore surface: 0.59–0.64 mm^2 and a perimeter of 3.38–3.20 mm. After finishing, the Spacer-type structures have a high mass (> 65 g / m^2). The analysis of the elemental composition shows that elemental Ag is found in the largest share in both structures (49–46%), followed by Carbon (22–27%), Indium (9%), Tin (4–5%), Chlorine (4%) and Oxygen (4%). The modulus of elasticity of the functional models (PES + PLA + Ag) and (PP + PLA + Ag) places them in the category of meshes with small modules (in both directions <10.95 MPa); the anisotropy of Spacer-type structures is very good, being in both cases <1.0 (0.90, respectively 0.51).

REFERENCES

[1]. Palash Paul, DP Gon Knitted Spacer Fabric-ManufacturingTechnic and Application,Technical Textile.net, A Fibre2Fashion Venture

[2]. Shanna M.Bruer, Nancy Powell, Gary Smith, Tree - Dimensionaly Knit Spacer Fabrics: A review of Production Techniques and Application, Journal of Textiles and Apparel,Technology and Management (JTATM), Vol 4,Issue 4,Summer 2005

[3]. Narayan Gokareshan ,Velumani K, Some: Significant Advances Spacer Fabrics Technology for New Areas of Application, Journal of Textile Science&Engineering, ISSN 2165-8064,2018, 8:1, DOI:10.4172/2165-BO64.1000339,Vol 8-Issue1-1000339

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Email id: ijaem.paper@gmail.com